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# THE Popular Science Review.

A QUARTERLY MISCELLANY OF ENTERTAINING & INSTRUCTIVE ARTICLES ON SCIENTIFIC SUBJECTS.

EDITED BY JAMES SAMUELSON,

AUTHOR OF "THE EARTHWORM AND HOUSEFLY," "HONEY-BEE," ETC.

## CONTENTS.

INTRODUCTION.

CORN. By Professor JAMES BUCKMAN, F.L.S., F.G.S., F.S.A. Illustrated by the Author.

THE DAISY. By Mrs. LANKESTER. Illustrated by J. E. Sowerby.

THE CROWN ANIMALCULE. By P. H. GOSSE, F.R.S. Illustrations by the Author, engraved by Tuffen West, F.L.S.

THE LOWEST FORMS OF LIFE. By the Editor. Illustrations by the Author, and Dr. J. B. Hicks, F.L.S., engraved by G. H. Ford and Tuffen West, F.L.S.

IRON AND STEEL. By Professor ROBERT HUNT, F.R.S.

ARTIFICIAL LIGHT. By Professor ANSTED, F.R.S.

THE BREATH OF LIFE. By W. CROOKES, F.C.S.

THE WEST COAST OF EQUATORIAL AFRICA. By the Editor. With a Coloured Map.

THE GREAT COMET OF 1861. By JAMES BREEN. Illustrated by the Author.

REVIEWS:—

THE PAST AND PRESENT LIFE OF THE GLOBE.

HOUSE DOGS AND SPORTING DOGS.

BOOKS SUITABLE FOR POPULAR PERUSAL OR INSTRUCTION.

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THE LIVERPOOL AND MANCHESTER FIELD NATURALISTS' SOCIETIES.

REWARDS AND HONOURS FOR PROFICIENCY IN SCIENCE.

QUARTERLY RETROSPECT.

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# POPULAR SCIENCE REVIEW.

## CONTENTS.—No. I.


PAGE

INTRODUCTION. . . . . 3

CORN. By Professor JAMES BUCKMAN, F.L.S., F.G.S., F.S.A. Illustrated by the Author . . . . . 9

THE DAISY. By Mrs. LANKESTER. Illustrated by J. E. Sowerby . . 17

THE CROWN ANIMALCULE. By P. H. GOSSE, F.R.S. Illustrations by the Author, engraved by Tuffen West, F.L.S. . . . . 26

THE LOWEST FORMS OF LIFE. By the EDITOR. Illustrations by the Author, and Dr. J. B. Hicks, F.L.S., engraved by G. H. Ford and Tuffen West, F.L.S. . . . . 50

IRON AND STEEL. By Professor ROBERT HUNT, F.R.S. . . . . 61

ARTIFICIAL LIGHT. By Professor ANSTED, F.R.S. . . . . 80

THE BREATH OF LIFE. By W. CROOKES, F.C.S. . . . . 91

THE WEST COAST OF EQUATORIAL AFRICA. By the EDITOR. With a Coloured Map . . . . . 100

THE GREAT COMET OF 1861. By JAMES BREEN. Illustrated by the Author . . . . . 111

REVIEWS:—

"THE PAST AND PRESENT LIFE OF THE GLOBE" . . . 116

"HOUSE DOGS AND SPORTING DOGS" . . . . . 118

BOOKS SUITABLE FOR POPULAR PERUSAL OR INSTRUCTION . . 120

MISCELLANEA:—

THE LIVERPOOL AND MANCHESTER FIELD NATURALISTS' SOCIETIES 123

REWARDS AND HONOURS FOR PROFICIENCY IN SCIENCE . . 126

QUARTERLY RETROSPECT . . . . . 128

THE POPULAR SCIENCE REVIEW, No. II.,

. . . . . .

*will contain, amongst other entertaining and instructive matter:*

THE PHOSPHORESCENCE OF THE SEA. By M. A. de Quatrefages, author of "Rambles of a Naturalist," &c.

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# INTRODUCTION.

THERE is a tale told of a wealthy farmer who had a lazy and improvident son, whom he called to his bedside in his dying hour, to inform him that in a certain part of his farm he had concealed a treasure. Before he had time, however, to state the precise locality in which it was hidden he was overtaken by death, and prevented from completing the revelation.

The narrative goes on to say that as soon as the old man's spirit was departed, the son delved over every portion of his farm in search of the treasure; and in order the better to conceal his object, he at once caused the soil to be prepared for the sowing season. The precious hoard was nowhere to be found; but owing to the thorough tillage to which his land had been subjected, his first crop was so prolific that it encouraged him to further industry; and growing in substance, he forsook his indolent ways and became a wealthy and respected yeoman.

This story, which is no doubt familiar to most of our readers, is remarkably figurative of man's progress in scientific knowledge. There is another Father; and one of the means employed by Him to develop the noblest powers of his children (often turning them from evil to good courses), is the appeal to their love of gain. A moment's consideration will suggest to every thoughtful reader familiar illustrations of this truth, and we venture to say that every number of this Journal will contain statements of facts by which it will be corroborated.

One example, however, appears to us more striking and appropriate than any other, and it is this:

The desire to become possessed of immense treasures induced the representatives of science, in former times, to deny themselves almost every earthly enjoyment. Secluding themselves

from society, they pored over philosophical works, and passed whole days and nights in experimenting upon the elements, and in submitting the baser metals to every conceivable process, with a view to their conversion into gold.

We have his picture before us—the old alchemist! There he sits in his vaulted chamber, upon his carved, high-backed arm-chair. His head, of which little else is visible than his long flowing hair and beard, leans upon his left hand, whilst with the right he turns over the pages of some mouldering volume in search of the "hidden treasure." Around him may be seen the emblems of his craft. In one corner is a small furnace, fitted with a primitive pair of bellows, on which stands an iron still. Mortars, pestles, crucibles, air-pumps, weights and scales, flasks, funnels, pincers, jars, and vessels of every kind lie scattered about in confusion. On a board or rude table, surrounded by these appliances, sits *the* great black cat, and, suspended over the head of the hoary philosopher, the stuffed owl with outspread wings sways gently to and fro.

They never found the hidden treasure, these misguided but persevering workers, but they broke through the hardened incrustation of ignorance in which mankind was buried in their day; and it was left for their posterity, for practical men of science, to prepare the soil, sow the seeds, and reap the golden harvest. And what, after all, was the object they sought to attain, compared with the indirect results of their labours? They desired to convert the baser into the more valuable metals.

This has since been accomplished; but so much more wonderful have been the other victories of science, that this one is barely known to the world. Who cares to be informed that whole services of plate which grace the banquets of the affluent have been wrought from silver extracted from the crude ore of lead? or that the brilliant ornaments of aluminium which adorn the persons of the fair have been tortured from a lump of despicable clay?—ay, from the meanest soil whereon you trod, and which was not deemed worthy of your regards, profound philosopher and alchemist!

What, we ask, are these benefits compared with the magic influence which lulls the sufferer to sleep and spares him all the anguish of a painful operation? or with the silent messenger that speeds from land to land with news of life and death, of peace and war, outstripping Phœbus in his course; or to the vapoury element which, when confined and controlled, bears its master on his journeys over land and sea like some mighty "Genius" of the East; or, in the stillness of night, conveys intelligence, borne on the wings of lightning from the farthest corners of the earth, and, multiplied indefinitely by this self-same power, to the home of every family throughout the length and breadth of the land.

But there is still another lesson of importance suggested by the simple story of the farmer's son.

He delved with a view to enrich himself alone, but the fruits of his toil supplied the wants of many. So has it been with regard to science. Had some alchemist been enabled through a mysterious process to convert the baser metals into gold, he would have amassed enormous stores of wealth, and with them hoarded up the secret of their production, and carried it with him to the grave.

But it has been wisely ordained by Providence that the spread of knowledge should be gradual, not only in this, but in every other particular; and the unfolding of nature's secrets has necessitated the united efforts of many minds. The principle of combination, whilst it has lightened the labours of the student, has aided materially to enrich our stores of knowledge, and the greater the harvest becomes, the more numerous will be the husbandmen. The men whose avocation it is to penetrate nature's secrets, do not now, as formerly, work alone, secluded from the world, and surrounded by mysteries impenetrable to the vulgar gaze, as were their ancestors. They vie with one another in imparting, not in concealing, information; and the thoughtful sage who spends his nights in study may be seen in the broad light of day rambling through country lanes surrounded by anxious inquirers—youths and maidens, the aged

and young—all anxious to secure a little of the knowledge which he has secured at the cost of so much toil, but now dispenses with such a liberal hand.

Indeed, the reserve of bygone days has passed away, the patent for man's wisdom has expired, the microscope and telescope, the printing-press and all the other aids to scientific progress, are the guide-posts to the traveller on the road to knowledge.

But still the path of the adventurer who dedicates his noblest powers to science is far from smooth. Departing from the shores of the "great ocean of truth" (as the wisest man of modern days has called the province of research), he commences the ascent of one of the precipitous acclivities that rise on every side. Here, as he scrambles up from rock to rock, each step he mounts places within his reach fresh works of interest and wonder. These he collects, and, wearied soon with his exertions, stops to rest. But only in one sense does he rest. Adventurers less active than himself are scrambling up the heights, and cheerfully he lends a helping hand to each as he approaches. And should he, looking down, perceive some undecided pilgrim, doubtful whether the reward is worth the venture, he casts the waverer a hard-earned treasure to lure him on, and show how tempting are the prizes that await him if he persevere.

And then he contemplates the glorious scene around, and in the widening prospect finds fresh courage to resume his upward course.

Onward he goes, and at each turn he finds fresh treasures, meets with new surprises, and a still extending prospect.

'Tis true, the higher he mounts the fewer are his comrades; but then the atmosphere becomes more pure and more invigorating, and greater his anxiety to reach the summit.

At length it is attained; the final effort being perchance the greatest; but what a recompense rewards his arduous ascent!

Beneath him roll majestically the clouds that hid the clear

expanse which now spreads out in purest azure overhead! He sees the limits of the mist that often well-nigh blocked his path, and still envelopes his less nimble fellow-travellers; whilst at his feet lie many provinces and departments, all grouped in harmony and constituting Nature's realm.

What next!

Shall he, exhausted, lie him down and rest upon the summit? contemplate with indifference the fruitless efforts of those who seek to follow in his track? or smile contemptuously upon the ignorant flounderers in the pools below?

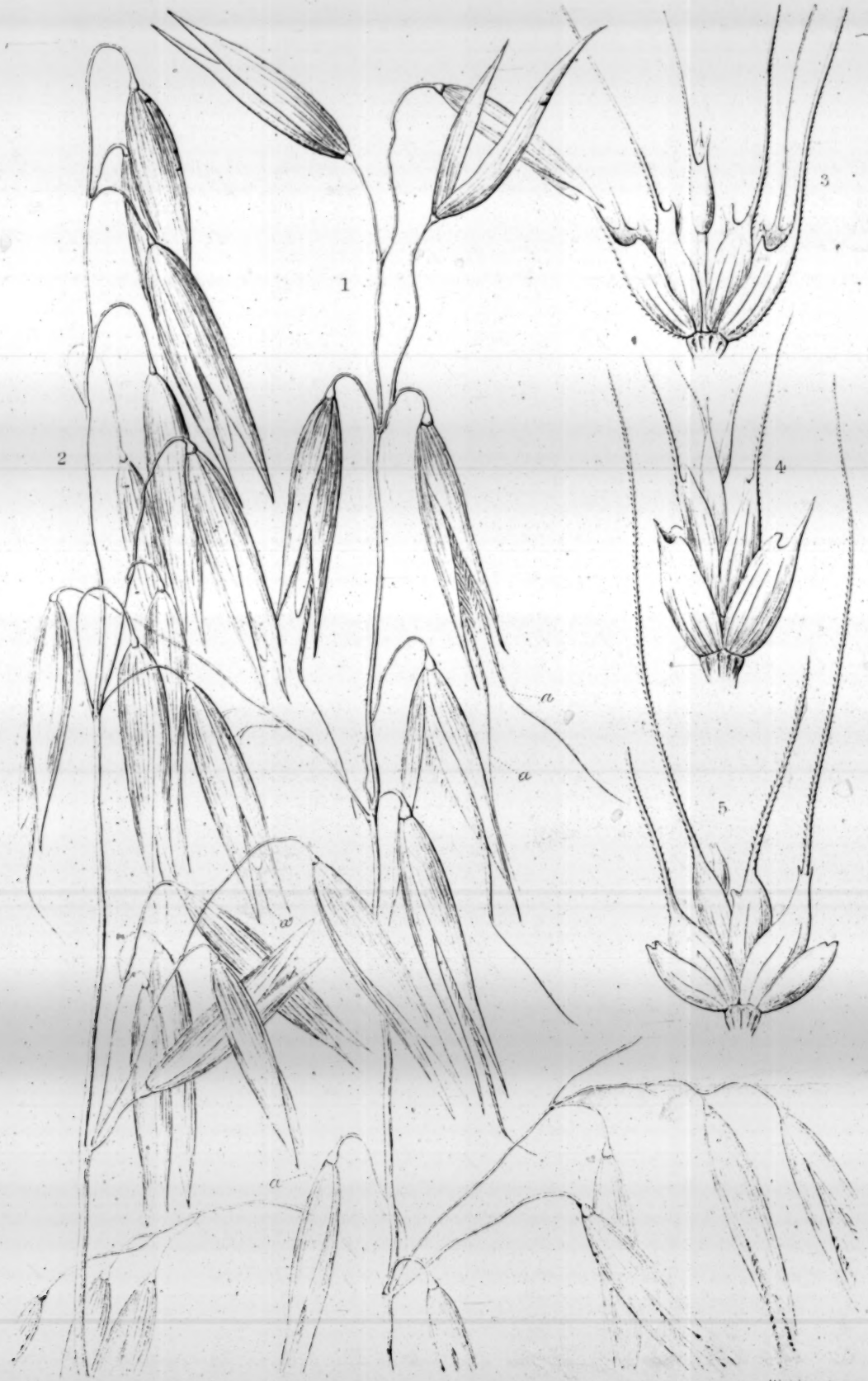
No! no! If he but raise his head and gaze into the infinite blue dome above, he will perceive the approving Eye that watched him in his upward course, and will obtain a glimpse, however faint, of the Creator-Sovereign of the realms below. To Him he should direct the attention of his fellow-labourers still toiling up the heights, and thus encourage them once more to persevere.

He should not plume himself upon his own successes; but should employ them for the good of others. This is the high prerogative of every advocate of scientific truth.

"Truths that the learn'd pursue with eager thought
Are not important always as dear bought,
Proving at last, though told in pompous strains,
A childish waste of philosophic pains;
But truths, on which depends our main concern,
That 'tis our shame and misery not to learn,
Shine by the side of every path we tread
With such a lustre, he that runs may read.
'Tis true that, if to trifle life away
Down to the sunset of their latest day,
Then perish on futurity's wide shore
Like fleeting exhalations, found no more,
Were all that heaven required of human kind,
And all the plan their destiny design'd,
What none could reverence all might justly blame,
And man would breathe but for his Maker's shame.
But reason heard, and nature well perused,
At once the dreaming mind is disabused.
If all we find possessing earth, sea, air,
Reflect his attributes, who placed them there,
Fulfil the purpose, and appear design'd
Proofs of the wisdom of the all-seeing mind;
'Tis plain the creature, whom He chose to invest
With kingship and dominion o'er the rest,
Received his nobler nature, and was made
Fit for the power in which he stands array'd;
That first, or last, hereafter, if not here,
He, too, might make his author's wisdom clear,
Praise him on earth, or, obstinately dumb,
Suffer his justice in a world to come."

COWPER.

Plate I.




J.B. del. Tellier lith. sc. Wilson imp.

COLD.

# CORN.

BY JAMES BUCKMAN, F.G.S., F.L.S., F.S.A., ETC., PROFESSOR OF GEOLOGY AND BOTANY IN THE ROYAL AGRICULTURAL COLLEGE.

THE notion entertained by the ancients, that corn was the gift of the beneficent goddess Ceres, may not improperly be held to express the fact that they knew little, if anything, of its natural origin, and that with them the need of reflection was obviated by attributing the possession of corn to a special divine interposition.

The honour paid by the Romans to the "bountiful goddess" may be gathered from the care which they evinced in depicting her form and attributes.

The representation of Ceres, on a tessellated pavement, discovered at Cirencester (*Corinium* of the Romans), gives no bad notion of the dignified treatment of which this kind of subject was susceptible, when, even with potsherds and bits of different coloured stones, the artist, aided as he must have been by profound veneration and deep religious feeling, produced a design of so much grandeur as to elicit from Mr. Westmacott, the Royal Academician, the observation: "These interesting specimens satisfy me, as an artist, beyond the shadow of a doubt, that such works were produced after examples of the very highest reach of art."*

But, however much the ancients may have venerated Ceres for her gift of wheat, &c., the care with which every natural object has been studied in our day has conduced to the conclusion that the so-called Cereals, in all the varieties employed by man for different purposes, were not *created* in the forms they now assume, but that they have been *derived* by cultivation from wild plants very different indeed from the civilized types with which we are at present acquainted under the collective name of Corn.

In England, wheat, rye, barley, and oats, are spoken of as corn; in the United States the *Zea Mays* (maize or Indian corn) enjoys that title solely; whilst different sorts of grain are mentioned under their specific names.

The scientific agriculturist, recognizing corn-plants as belonging to the natural order *Graminaceæ* (in other words, as

* This opinion was founded on a study of the figures of Ceres, Flora, and Pomona.

being but an elevated *grass*), divides this order into two groups.

Firstly, CEREAL GRASSES (corn). Those yielding a seed large enough to be collected and stored as food for man and the inferior animals; and, Secondly, MEADOW AND PASTURE GRASSES, in which the whole plant is employed as pasturage, or fodder for cattle.

The seed-grain of the cereal grasses, then, forms the corn crop; and our own experiments, particularly with regard to the oat, show that our cultivated varieties, with their plump seeds, are derived from a wild oat, the seeds of which are entirely valueless—in fact, the whole plant is a weed, the mischievous nature of which is fully recognized by society when it speaks of a reformed profligate as having sown his wild oats.*

SPIKELET OF THE WILD OAT.
(*a a*, the Hairy Seeds, simulating a Fishing-Fly.)

The seeds of the wild oat are covered with stiff bristles (fig. 1) of a brown colour, and this, with the long bent awn, is in appearance so much like an insect, and the contortions caused by the untwisting of the awn as it touches the water so nearly imitates the behaviour of a struggling fly, that the country urchin employs it with success as a bait for trout, whilst the Waltonian, with his ingeniously constructed "artificial fly," may get little more than his exercise for his pains.

The wild oat is botanically known as *Avena fatua;* it grows from three to five feet in height as a weed in corn and pulse,

* We recollect once, whilst on a visit to a farmer in Worcestershire, having seen the weed-oat growing for the first time, and, though then on our way to church, we could not resist the temptation of plucking a specimen, which was at once consigned to our sabbatical botanical vasculum, namely, our hat; the contents of which were noticed by our friend, and elicited from him the serious (?) remark: "Ah, sir, what is the good of your going to church if you don't leave your wild oats behind you?"

in which, of course, it is a great pest, if only from the circumstance of its encumbering the ground, and so preventing the growth of the required crop.

About ten years since we collected some of the seeds of this weed (see engraving, fig. 1), and in the following spring commenced its cultivation in our experimental plots at the Royal Agricultural College; and so, year by year, we saved seeds; and in 1855 we were enabled to report the following changes:—

1st. A lighter-coloured fruit.

2nd. A less degree of hairiness, when compared with the fruits of the true *Avena fatua*.

3rd. A greenish-coloured, straight, and slight awn,* in place of the black rigid one, bent at right angles, and twisted at the lower part, which characterizes the wild plant.

4th. The fruits were much more plump, arising from a greater development of grain, than in the truly wild state.

5th. The ripe fruit separated from the floral envelope less readily than in *A. fatua*.

In 1856, seed with the characters just described was sown in a prepared bed, and the result was a large admixture of two forms or types of crop oats, one with the flowers all round the stem—the "potato oat" form of the farmers; and the other with the flowers all drooping to one side—"the so-called Tartarean oat." (See engraving, fig. 2.) Since then we have grown these sorts so derived, in the field, and with a gradual improvement in point of productiveness and weight per bushel, an item which no horse-keeper will fail to appreciate.

These experiments, then, have been of great interest, not only as proving that a cereal grass is derived from a wild or meadow grass; but that the remarks of old farmers, who, in some situations, objected to grow oats as a crop, "because they degenerated into the wild weed-oat," are founded on fact; *and it is a curious and interesting example of experience forestalling science*. This matter is further of great interest to the vegetable physiologist, as now we have, by experiment, obtained cultivated oats from wild ones; and since then we have watched the production of *wild* oats as a gradual degeneration from cultivated ones.

Wheat.—If one vegetable production more than another has come to be considered a direct gift to man, handed down to him in an unaltered state from the most remote periods, it is wheat; yet, when we consider the enormous number of varieties of this plant found in different parts of the world, and remember, too, that new sorts are introduced almost every year, we cannot help being struck with the capabilities of wheat to assume a variation, not only in external form, but also in differences in quality,

* The beard or bristle.

and with its power of adaptation to very variable conditions, such as those of climate, soil, and modes of cultivation.

Let us then start from the point of view afforded to us by an examination of the two more prominent English forms of wheat, which may be thus epitomised. *Triticum hybernum* — ear compact, smooth, or nearly so, beardless (smooth beardless wheats). *T. vulgare* — ear more or less hairy, with beard (awn) of greater or lesser length (hairy, bearded, or cone wheats). Of these there are so many varieties, that it would be almost impossible to enumerate them. Commencing then with these, we have to premise that, although their extreme differences are so great, yet they, after all, merge into each other; and we are justified in concluding that, as the sorts of wheat differ so much among themselves, the cultivated wheat-plant is derived from a wild grass. It may be remarked also, that nowhere is the wheat-plant found wild in any form at all resembling any cultivated variety. However, to quote the language of Mr. Bentham, in "Morton's Cyclopædia of Agriculture," article *Triticum*:—

"It has never been contended that their original types have become extinct, and various, therefore, have been the conjectures as to the transformations they may have successively undergone; and as no accidental returns towards primitive forms have been observed; we have, till lately, had but little to guide us in these vague surmises. Within the last few years, however, the experiments and observations of M. Esprit Fabre, of Agde, in the South of France, seem to prove a fact which had been more than once suggested, but almost always scouted, that our agricultural wheats are cultivated varieties of a set of grasses common in the South of Europe, which botanists have uniformly regarded as belonging to a different genus, named *Ægilops*. The principal character by which the latter genus had been distinguished, consisted in the greater fragility of the ear, and in the glumes (*i. e.* the chaff-scales) being generally terminated by three or four, and the pales by two or three points or awns (beards). But M. Fabre has shown how readily these characters become modified by cultivation; and wide as is the apparent difference between *Ægilops ovata* and common wheat, he has practically proved their botanical identity; for, from the seeds of the *Ægilops* first sown in 1838, carefully raised in a garden soil, and resown every year, from their produce, he had, through successive transformations, by the eighth year (1846) obtained crops of real wheat as good as the generality of those cultivated in his neighbourhood."

A paper on this interesting subject, by M. Fabre himself, will be found in the "Journal of the Royal Agricultural Society of England," the following note upon which, from the pen of Professor Dunal, will not be devoid of interest:—

"The foregoing observations show that *Æ. ovata* (L.), is capable of being extremely modified under certain circumstances. Whilst its floral envelopes lose their width and some of their awns, and thus become like those of *Triticum*, their stems, leaves, and ears become more and more developed, and at length acquire all the characters of wheat. The necessary inference is, that some, if not all, cultivated *Tritica* are peculiar forms of *Ægilops*, and

ought to be regarded as races of this species. If this be admitted, it is easy to reconcile the accounts given of the origin of wheat. It has been said, both in ancient and in modern times, that wheat was wild in Babylonia, Persia, and Sicily. In all these countries *Ægilops* is common, and it is not surprising that some of its species may have accidentally acquired a wheat-like form, and have been afterwards improved and propagated by cultivation. Thus to M. Esprit Fabre is due the merit of having ascertained the true origin of cultivated wheat. Its origin had, it is true, been suspected and vaguely pointed out by several persons; but the honour of a discovery is really due, not to the authors of a surmise, but to him who has established the fact by observation, experiment, or reasoning, leaving no room for further doubt."

Now, it was the description of these experiments that determined us to obtain some of the seeds of the *Æ. ovata*, and submit them to cultivation. Our first sowing was in the year 1855, in the experimental garden of the Royal Agricultural College; but, probably owing to the cold climate of the Cotteswolds, upon which chain the College is situate, the annual changes were but slight; but in the warm summer of 1859 our plot of specimens had made great advances, which may be best explained by reference to our engraving.

Fig. 3 represents a spikelet of a type of *Ægilops ovata* such as we introduced into our garden.

Fig. 4. A spikelet of the same kind of grass modified by cultivation, 1859.

Fig. 5. An ear of bearded wheat.

Our crop of last year had not improved, but it is curious to note that this wet season produced in this grass all the ordinary blights on the stalks, leaves, and ears that usually belong to degenerate or badly grown wheat crops in this country, and more particularly those black dots of fungi on the stems and leaves called mildew.

Due reflection, coupled with the experiments to which reference has here been made, especially when combined with the tradition that the gift of wheat corn came from the East, would lead to the inference that a wild eastern grass was operated upon by the cultivator in very early times—indeed, at a period so remote as to be referred to the ancient gods; and the result was the production of a grain probably not so good as we grow in these days of advanced agriculture, but one in which the necessary changes were brought about from the large-seeded *Ægilops* to a still larger and so useful grain; and this transformation would of course be accelerated by the warm climate in which it was effected.

The subject of the production of new varieties of wheat is one of great national importance; for inasmuch as our wheat, like most other plants of cultivation, are but derivative forms or induced varieties, it follows that with long growth in any one district a particular sort is liable to become degenerate.

It may be said, indeed, that no crop is absolutely without a new variety. This may be selected and cultivated; and should the qualities for which it is chosen remain permanent, and be found valuable, its extension over the whole country is insured by means of advertisements, and by the reports of the large crops produced therefrom, and its value enhanced, securing a reward to the cultivator, to which he is justly entitled as a compensation for his toil. One of the more recent introductions of this kind is "Morton's red-strawed white wheat," the history of which is described in the "Cyclopædia of Agriculture," vol. ii. page 1131.

Another point of public interest is that, although our forefathers eat rye and barley bread, and that often of a very questionable dark colour and made from a very inferior grain, bread from these kinds of grain is now almost if not quite unknown in England. Not only do the masses now eat wheaten bread, but the drainage of our lands and better farming have greatly tended to the spread of the *finer* kinds of wheat all through the country.* All classes, then, are deeply interested in agricultural improvements, for not only do they tend to increase the quantity, but also to improve the quality, of human food.

We now turn to RYE; to illustrate the history of which for our present purpose we cannot do better than quote the following from the pen of Professor Lindley:—

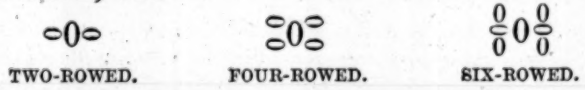
"*Secale cereale* (the common rye) is a cereal grass, distinguished from wheat by its narrow glumes, and constantly twin narrow florets, with a membranous abortion between them. Otherwise it is little different in structure, although the quality of its grain is so inferior. According to Karl Koch, it is found undoubtedly wild on the mountains of the Crimea, especially all around the village of Dishimil, on granite, at the elevation of from 5,000 to 6,000 feet. In such places, its ears are not more than one to two and a half inches long. Its native country explains the reason why it is so much hardier than any variety of wheat, the southern origin of which is now ascertained."

Rye, more especially under bad farming, is subject to a malformation of the grain, by which it becomes elongated in the form of a black spur, which is seen projecting from the chaff-scales. This, which is known to the apothecary as *Secale cornutum*, is used in modern obstetric practice. As it was formerly ground up in the flour of the affected rye, the constantly partaking of so potent a drug in even small quantities is said to have produced the most fearful results, not only in man, but in the inferior animals who fed upon its grain or bread, such as decay and gangrene of the extremities, frightful convulsions,

* It is well known that in large towns, such as Liverpool, the working classes will have the very finest flour, whilst the middle classes mostly consume best seconds.—ED.

and death. Happily, those improvements which enable us now to cultivate a less hardy grain (for such was wheat formerly, with greater reason than at present, held to be), have in our day freed man from those devastations which a bad year of rye entailed upon the human family in times gone by.

BARLEY, the last cereal on which we shall comment, is practically known under three forms according to the arrangement of the seeds, viz.—



TWO-ROWED. FOUR-ROWED. SIX-ROWED.

The two-rowed forms are those ordinarily cultivated in England; the six-rowed is more grown in Scotland, where it is known under the name of Bere. The four-rowed is, perhaps, only a variety of the six-rowed, as, in fact, may be the two-rowed—being, in one case, an abortion of a single seed in each spikelet; and in the other, the non-perfecting of two seeds; the whole spikelet having perfect seeds in the bere.

Barley belongs to the botanical genus *Hordeum*, but very various have been the opinions as to the wild species from which it has sprung. In all probability Professor Lindley's remark upon the *Hordeum distichum* is somewhat near the mark:—

"*H. distichum.*—This is the only kind of barley that has been found apparently wild. We have now before us specimens gathered in Mesopotamia, during Colonel Chesney's expedition to the Euphrates, with narrow ears, little more than an inch long, exclusive of the awn (beard), or four and a half inches, awn included; and others from the ruins of Persepolis with ears scarcely so large as starved rye. Both are straw-coloured, but that from Mesopotamia has the glumes much more hairy than the others."

The varieties of cereal barley are probably all derived from this type, or at least all the two-rowed ones; but still with us it is a matter of doubt whether the specimens just described are not after all derived from cultivation.

The *H. hexastichum*, six-rowed barley, or bere, in Scotland also called "big," of which there are several varieties, has been recommended from time to time to the English farmer. As Morton observes, "some enterprising farmer brings them out as novelties," while perhaps they have little else to recommend them."

"It is only lately (1848)," says the same authority, "that a considerable sale of black barley, at high prices, for seed, was effected by the advertisement of a story connected with it, which was singular enough to attract attention. The whole of the stock it was stated, was raised from a seed taken from the crop of a goose shot on Lake Simcoe, in West Canada, whilst on its southern autumnal flight. But there was no need for the Canadian sportsman to have sent us the produce of this solitary

grain, for we have abundant stock of these varieties at home, as would long ago have been known to farmers in general, if either of them had deserved a more extended cultivation."

There is an old couplet which informs us, that—

"Turkey, carp, hops, pickerel, and beer,
Came into England all in one year."

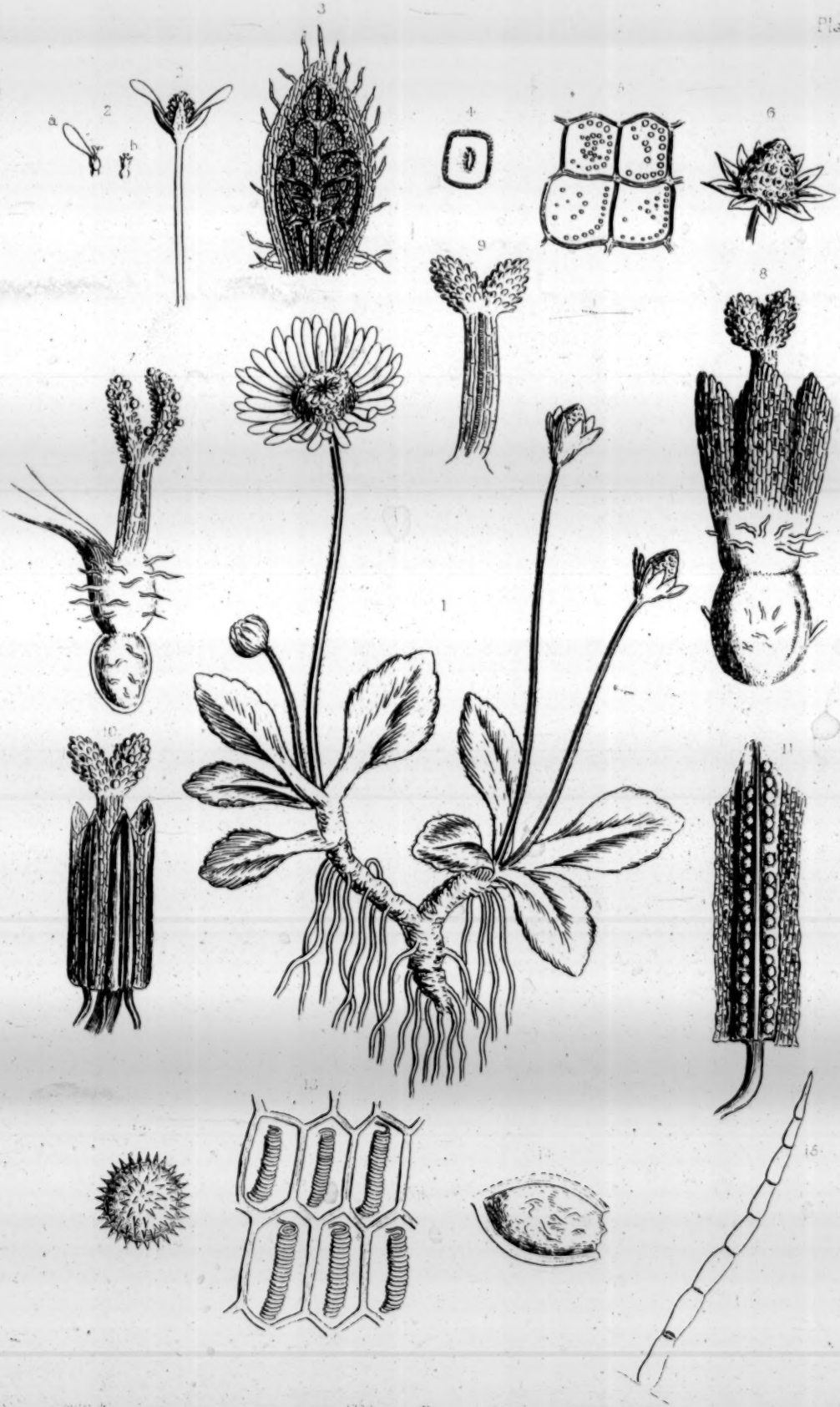
Now, as we incline to the belief that beer was known in England before turkey, carp, or hops, it is not improbable that this refers to the introduction of the *bere*, or big-barley, which latter is, in fact, still much grown in Scotland, being favoured by the climate; but the two-rowed variety not only grows better in England, but commands a higher price.

In bringing these notes on Corn to a conclusion, we would express the hope that our remarks have not been of too professional or technical a character for the readers of this Journal. To some extent they have been necessarily so, for it would otherwise have been impossible for us to draw attention to the all-important fact, that the corn-grasses are useful in consequence of the size and variety of the grain, and that these desiderata have only been acquired by careful cultivation. Reference might indeed be made to many more general truths in connection with the subject. It is our belief, on which we might have enlarged, that the production of more delicate and finer sorts of grains of every kind accompany a more extended civilization and a better class of farming; in fact, that grain is as susceptible of cultivation as is man himself, and that the one can no more remain at a standstill than the other. Nay, we may even carry the analogy still farther; for a degree of over-refinement in the plant is as productive of disease and degeneration as in the human being, so closely does the history of corn appear to be allied to that of our race.

Nor must it be supposed that the professional man is incapable of regarding the object of his studies solely in a utilitarian spirit — that he does not see in it something beyond mere drudgery A "harvest home" is to us, at least, as joyful a spectacle as to the farmer whose grain is housed, and, we venture to say, in many instances, a more instructive one.

"The harvest song we would repeat:
'Thou givest us the finest wheat;'
'The joy of harvest' we have known;
The praise, O Lord! is all thine own.

"Our tables spread, our garners stored;
O! give us hearts to bless thee, Lord!
Forbid it, Source of light and love,
That hearts and lives should barren prove."




The Daisy

# THE DAISY.

BY MRS. LANKESTER.

THERE are few plants which excite more general interest than the daisy. Growing extensively throughout the continent of Europe, its true home may, nevertheless, be said to be in the British islands. The very name speaks for itself; the "day's eye," as Chaucer, our old English poet, has it—

"The daisie, or els the eye of daie."

The daisy, botanically known as *Bellis perennis*, belongs to the natural order *Compositæ*, of which it may be taken as a type. Possibly, to those who know nothing of the general structure of this order, the daisy may present some difficulties, and it will, therefore, be preferable, in the first instance, to employ a larger flower of the same order for observation. The Sun-flower, the French Marigold, or the Ox-eye Daisy form good examples. First let us consider the flower-head, surrounded as it is with a bright green cup, or involucre, and having the appearance of a single flower, called by old writers a *compound flower*, with a *common calyx*. It is in fact, however, a number of florets situated on a common head, or receptacle, the enlarged summit of the peduncle, or flower-stalk, is, as it were, expanded at the top, to admit of the introduction of the flowers. Thus, in a raceme, or long stalk of florets, they are situated at the sides of the flower-stalk. Were it possible to convert this into a composite flower, it would be done by pushing it down, as it were, until it spread out in every direction; the florets would then be fixed upon the expanded stalk now forming a receptacle. In the *Compositæ*, the receptacle is usually covered with chaffy scales, or hairs, which form interesting objects under the microscope. The involucre surrounds the receptacle, and consists of a number of bright green bracts, in some cases adhering together at the edges, in other cases distinct. Within this involucre are placed the florets, which are either all ligulate, that is, flat, linear, or oblong, forming only a short tube at the base, or the flowers are all tubular, or else the central flowers are all tubular and the outer ones all ligulate. In each floret the calyx is attached to the top of the ovary, and assumes the form of long feathery hairs, or *pappus*, as it is called, which, when the florets dry,

and fall off, still remain bleached almost white, and are familiar to us in the dandelions and thistles, where they are wafted away by the wind, like parachutes, bearing at their base the tiny fruit which is to perpetuate the plant. Inside the tube of the corolla we find the stamens, usually numbering five, sometimes four; they are adherent by their filaments to the corolla, and the anthers are united to each other in every case. This union of the anthers is one of the chief characters of the plants belonging to the order *Compositæ*.

The fruit of Compositous plants consists of a single little nut, placed immediately on the receptacle, below the pappus, to which it is attached, and this nut contains a single seed. The appearance of these fruits differs but slightly in the tubular and ligulate florets. In the disk, or central portion of the flower, the pappus which crowns the fruit is more perfect than in the ray, and frequently one of its hairs is elongated into a sort of stiff bristle.

The involucre has the power of opening when the flower expands, and of closing when the florets fall off, in order to inclose the young seed, and to protect it while ripening; it also opens and turns quite back as the fruits increase in size and become matured. This is particularly remarkable in the dandelion.

In order to facilitate the arrangement of this family of plants, it has been divided by botanists into three sub-orders.

First, *Cichoraceæ*, the Chicory or Lettuce sub-order or section, in which both the ray and the disk are composed of ligulate flowers alone, to the exclusion of all tubular ones. They are remarkable for their stems yielding a white, milky juice, which, when concentrated, has a soporific quality in some species. Some plants of this section are esculent, and are eaten as salads, such as the lettuce *(Lactuca sativa)*.

The second section, or sub-order, is known by the name *Cynarocephalæ*, the Thistle-headed section. They have no ligulate florets, but consist entirely of tubular florets, generally very wide at the mouth. The common artichoke (*Cynara Scolymus*), as well as the various forms of thistles, belongs to this division.

The third section of Compositæ is the sub-order *Corymbiferæ*, the Chamomile section, with heads composed of both sorts of flowers, tubular and ligulate; the tubular ones are in the disk, the ligulate in the ray, hence they are called *radiate*. To this sub-order belong the asters, hence it is also called *Asteraceæ*. This is by far the largest section of Composite plants. To this division belong the Michaelmas Daisies, the Chamomile *(Anthemis nobilis)*, Leopard's-bane *(Arnica montana)*, the Dahlias of our gardens, the common Sunflower *(Helianthus annuus)*, the Colts-

foot, Marigold, Groundsel, Ragwort, Elecampane, the Chrysanthemum, and our special favourite, the common Daisy, of which we will now proceed to speak.

From the foregoing remarks on the order *Compositæ* generally, the family relationship of our little friend will be pretty well established. Nowhere has the structure and general appearance of the daisy been described so pleasantly as in some letters on the elements of botany, by the celebrated philosopher and poet, Rousseau, but he does not appear to have thought of going further into the subject than would be suggested by merely external observation. We have at this day so many appliances at hand to assist our investigations, that if we are disposed to make use of them, we shall find in our little plant much that is most interesting, hitherto undescribed. Having determined to study the daisy in all its parts, no subject can be obtained with less difficulty. Throughout Great Britain, we find its tiny bright flowers springing up on every "lawn and grassy plot," by waysides, on mountain-slopes; and in almost every country in Europe may we find

> "These pearled Arcturi of the earth,
> The constellated flowers that never set."

In the extreme north of Europe, however, and in America, it is not common, and is there treasured as a garden flower. Though not exclusively a British plant, yet so closely is the daisy associated with the earliest recollections of every native of the British isles, that we can scarcely wonder that it is especially dear to the wanderer from home in distant lands, and that it brings back recollections of rural scenes such as cannot be met with elsewhere. There is an old Celtic belief that each new-born babe taken from earth became a spirit which scattered down on the land it had left some new kind of flower to cheer its bereaved parents; the tale is thus told:—"The virgins of Morven, to soothe the grief of Malvina, who had lost her infant son, sung to her—'We have seen, oh Malvina! we have seen the infant you regret, reclining on a light mist; it approached us, and shed on our fields a harvest of new flowers. Look, oh Malvina! among these flowers we distinguish one with a golden disk, surrounded by silver leaves; a sweet tinge of crimson adorns its delicate rays; waved by a gentle wind, we might call it a little infant playing in a green meadow; and the flower of thy bosom has given a new flower to the hills of Cromla.' Since that day the daughters of Morven have consecrated the daisy to infancy. It is called the flower of innocence,—the flower of the new-born."

Leaving the regions of fancy and poetry, which, however tempting and delightful if indulged in without some previous

knowledge of facts as they really are, frequently mislead and confuse the mind, we will commence our close examination of the daisy by digging up as large a root of the plant as we can find. The inhabitant of a town or city has it almost as much within his power to study this botanical specimen as one who lives in the wildest country district, for there are but few places so entirely denaturalised as not to afford some space devoted to a park, green, or open play-ground. On such a plot of ground we may almost surely find the omnipresent daisy. Those who have gardens and grass-plots or lawns, be they large or small, know but too well how inveterately these little plants disperse themselves over the otherwise smooth green surface, and disturb the equal growth of the velvet turf. Much as we delight to see the poet's flower on "waste or woodland rock or plain," we may without compunction remove it from our garden carpets, and turn it to scientific account.

First let us observe the root, or roots we should say, for they are perennial, and in digging up what appears to be but one daisy plant, we are sure to remove several others. There is an original root-stalk or rhizome, which sends into the earth numberless fibrous rootlets; from each original plant proceeds one or more creeping stems or offsets, which at a distance of about an inch or so produce buds or other little plants which in their turn send down fibres into the ground and propagate themselves by other offsets (pl. ii. fig. 1). This mode of propagation does not extend indefinitely as in some plants with creeping roots, such as the Potentilla, for we do not often find more than two or three offsets attached to each plant. It would appear as though, after producing two or three new plants, the original connecting stem died away and left the young plants free.

Undoubtedly, the original plants are produced from the seeds, of which we shall presently speak; but the mode of propagation we have described is evidently very general in the daisy, for we seldom dig up a root without finding the attendant offsets attached to it.

The roots of the daisy have a slightly bitter astringent taste, and contain, in common with other plants of the same group, a portion of tannic acid. This principle has, however, never been separated, and it is doubtful whether the old recipe of "daisy-roots and cream" had more than a fancied efficacy.

Above the ground the daisy appears as almost interwoven with the materials forming the green carpet of our fields and pastures, so closely does it adapt itself to the circumstances in which it is found. In barren and uncultivated land it becomes a very dwarf, keeping its leaves very near the ground, and with its flower-stalk scarcely raised above the leaves. In rich mould and under favourable conditions its leaves assume a greater size,

the stalk rises several inches in height, and all its parts expand in proportion.

The leaves, of a bright grass green colour, appear above the ground at the end of the offsets, around which they are closely set; they are usually ten or twelve in number, shaped like a spatula or oval, with the end nearest the stem gradually narrowing off. The petiole or leaf-stalk can scarcely be said to exist. At all events, it appears more like the narrow continuation of the leaf than a petiole properly so called. These leaves are notched all round the broad end, which notches are tooth-shaped; they appear covered with hairs, which are depressed or lie on the surface of the leaf, and are more abundant on the lower side than the upper. The epidermis or cuticle exhibits a number of little openings, known as *stomates*, from the Greek *στόμα*, a mouth, which have the usual form and shape of those found in exogenous plants (pl. ii. fig. 4). These orifices allow a free communication between the external air and the internal tissues of the leaf; hence they have been called *breathing* pores. Some botanists have considered them as organs for the absorption of carbonic acid gas, which is the principal food of plants; but others, amongst them Schleiden, regard them solely as organs of exhalation, enabling the plant to throw off extraneous moisture. This view, which seems more probable than any other, is confirmed by the fact that stomates are entirely absent in succulent plants, and that in moist states of the atmosphere they are found closed, and in dry weather they remain open. There is but one rib up the centre of the leaf, the veins proceeding therefrom being hardly perceptible; but, by holding up the leaf to the light of a candle, they may be distinctly traced. Botanists describe the leaf of the daisy as obovate, spathulate, single-ribbed, crenate, dentate, which comprises in a few words what I have endeavoured thus to simplify and explain.

From the midst of the depressed whorl of leaves springs the simple flower-stalk, bearing at its summit the one flower head. Each little plant or circlet of leaves may send up one, two, or three flower-stalks. These are covered with hairs, which become thicker and more dense towards the top. These hairs resemble those on the leaf, but are shorter (fig. 15). In their early stage the flower-stalks are solid; but as they grow they become hollow in the centre, and the cavity is especially evident near the top; this is formed by the growth of the tissue of which it is composed being more rapid externally than internally (fig. 2). Like the stems of all other exogenous plants, the stalk of the daisy is composed of cellular pith in the interior, which is removed as it becomes hollow; then some layers of woody fibre and bundles of spiral vessels, which are covered with an outer covering of

delicate cellular tissue or epidermis. At the summit, the flower-stalk expands into a receptacle, which is of a conical form, and at first is filled up internally with cellular tissue. When the flowers and fruit have been perfected and fallen off, we find the receptacle left, and that it has become hollow like the stalk. At first the receptacle presents the form of a small protuberance, but as it gets older it assumes more of a sugar-loaf appearance, which is very decided when the flowers and fruits have fallen from it.

Around the receptacle are placed the bracts in two rows, one behind the other, forming an involucre, or, as botanists call it where the bracts overlap, a *Phyllary*. These bracts number from twelve to fifteen. In order to examine them perfectly we must use the microscope. Under a quarter-inch object-glass, we observe the centre portion of the bract to be denser and of a deeper green than the outer edges, which are almost transparent (fig. 3). The cellular tissue (fig. 5) of which they are composed is elongated at the margins into delicate hairs; this condition of the edges of the bracts, produced by the absence of *chlorophyle* (the green colouring matter of the leaf), when very decided, is known by the term *scarious*. The surface of the bract is ramified with delicate veins running symmetrically on each side of the centre vein, and the intervals present stomates such as we have seen on the leaves.

The receptacle on which the flowers are placed is covered with little elevations which, when the flowers die and fall off, mark the places where they stood (fig. 6).

In common with the rest of the tribe *Asteraceæ*, the flowers are of two kinds, ligulate and tubular (fig. 2, *a*, *b*). The outer white bodies which appear so much like the petals of other flowers, and are so frequently mistaken for them, are in reality the ligulate flowers of the plant, each perfect in itself. It is almost impossible without a magnifying glass or microscope to comprehend the true nature of these pretty little objects, which are well worth careful examination. There is no apparent calyx, neither do we find any quantity of the downy pappus, so abundant in some of the *Compositæ;* this organ seems to be represented by a few little hairs around the tube of the corolla in the daisy. The petal-like expansion is the monopetalous corolla of this ligulate flower (fig. 7). It is most frequently of a white colour, but in a large number of instances the tips of flowers will be found to be coloured pink. The pink colour sometimes covers the whole of the back of the flower.

The ligulate flower has no stamens or pollen-bearing organs, but has a single pistil which at the top divides into two branches forming stigmas (fig. 7). Under the microscope it is evident that the pollen grains produced by the tubular flowers, of

which we shall speak presently, have access to these stigmas, and so fructify the seed contained in the inferior fruit at their base. The whole body of the style is covered with delicate hairs. In the interior of the tissue of the style may be distinctly traced two or more spiral vessels, which are evidently continuous with those observed in the ribs of the leaves and in the flower-stalks.

Before speaking of the tubular flowers, we would draw attention to the fact that both the bracts and ligulate flowers move under the influence of the stimulus of light. In the evening these parts contract, and the whole head of flowers is "shut up," in order apparently to secure to the tubular flowers a night's repose. But, under the light of the next morning's sun, the bracts and ligulate flowers spread themselves out to the fullest extent, so as to allow all access to the beneficent rays of the sun. This movement of the parts of plants under the influence of the sun's light is very general, and is even more marked in some other compositous plants than in the daisy. Every one is familiar with the fact of the sunflower turning its noble head of flowers towards the east at the rising of the sun, and closes its large bracts over its tubular flowers whilst nodding to it in the evening towards the west.

The yellow tubular flowers forming the centre portion of the daisy appear at first sight similar to the stamens of other plants, and to the casual observer would pass as such (fig. 8). Viewed under the microscope they are individually a perfect flower; each one of these little yellow bodies contains in itself all the organs of the perfect flower. The edges of the five yellow petals unite to form a monopetalous corolla around the five stamens which enclose the pistil. These stamens having very short filaments, are united together by their anthers (fig. 10), which are twice as long as the filaments, and form beautiful objects under the microscope. Usually, in examining the anthers of plants we find the pollen generally diffused in irregular masses in the interior of the valves or anther-cases, of which most plants have two; but in the case of the daisy, the pollen is found lying in two regular even rows in the cavity of the valve (fig. 11). At the time of shedding the pollen, the valve which encloses this row of bead-like bodies bursts by a longitudinal slit, and allows their escape on to the pistil in the centre or on to the pistil of the ligulate flowers surrounding them. Under the microscope the inner layers of the valve of the anther are found to be composed of fibro-cellular tissue (fig. 13).

Each pollen grain is round, and covered with minute spines, and forms a beautiful object under the microscope (fig. 12). The pistil which rises in the centre of the flower has an elongated style in which are discernible the spiral vessels that exist more or less in the whole tissue of the plant. The

stigma or top part of the pistil differs from that of the ligulate flowers in that it is not so deeply cleft, and each branch is more conical than those of the formerly described stigma (fig. 9). They are covered with little processes or projections, which seem provided for the entanglement of the pollen grains that fall on them.

At the base of both ligulate and tubular flowers we find the fruit which contains a single seed. The structure of the fruits of plants is a study of itself, for on careful examination the fruit is found to be a very complicated organ. The minute example before us has its various parts in as great perfection as the largest fruit with which we are familiarly acquainted. There is the hardened *pericarp* (fig. 14), consisting of three membranes or layers, an external one called the *epicarp*, a middle one or *mesocarp*, and an inner one, the *endocarp*. In other fruits the middle layer being frequently of a fleshy or succulent nature, is also called the *sarcocarp*. Around the edge of the pericarp there is a sort of ridge or keel, which terminates at one end opposite to that where it was attached to the receptacle, and from which point the young seed or embryo sprouts forth. All over the surface of the fruit are minute depressed hairs, excepting on the keel, where there are no hairs to be seen. It does not appear that the single seed enclosed within this pericarp ever leaves its abode there; but, as it develops and grows, the walls of its habitation divide, and allow it to expand and grow beyond them.

Although this paper has been an attempt to enter as fully as possible into the microscopic structure and nature of this most interesting plant, there yet remains much to be done worthy the attention of the botanical student. The nature of the germination of the seed and the development of the earliest forms of the plant would supply materials for a series of experiments and researches.

It is well to remember that the forms and conditions of the daisy vary very much, according to the soil in which it grows and the circumstances under which it is found. In favourable soil the leaves attain a larger size, are of a brighter green, and the stalks of the flowers are much longer, than when we find the plant in poor and barren districts. As it approaches the sandy shores of the sea it becomes almost stunted, and produces small dark-coloured leaves and minute short-stalked flowers. In counting the number of flowers produced on one head under these various circumstances, we find that both the ligulate and tubular flowers vary from twenty to forty or fifty in number, the colour of the ligulate flowers is also very variable, from white tinged with pink to a deep pink scarcely showing any white whatever. In the cultivated garden daisy this is very evident; the tubular

flowers become almost, if not quite, obsolete, and their place is taken by ligulate flowers, which assume a deep pink colour.

In the variety known by the name of "hen and chickens," little flower-buds are formed in the axils of the bracts; sometimes as many as ten or twelve of these minute daisies surround the parent flower, thus suggesting its familiar name.

We can scarcely take leave of the little flower which has afforded us so much interest in the examination of its parts, without recurring to its poetical associations. The French name Marguerite has reference to the resemblance of its pearly bud to the rarer pearls of the ocean. Its Scotch name is *gowan*, and in Yorkshire it is recognized as peculiarly the flower of childhood, and is called *bairn wort*. In looking through old Gerarde's writings we find the daisy mentioned under the name of "*bruise wort*," as an unfailing remedy in "all kinds of paines and aches," besides curing fevers, inflammations of the liver, and "alle the inwarde parts."

We are not inclined to think with some writers that the botanical study and minute examination of this favourite flower in any manner detracts from its pleasant or poetical associations and simple beauty. The interest with which we have regarded each little starry flower, has increased tenfold since there has been revealed to us in that little circle multitudes of perfect flowers, each with its own organization, and in every leaf and stalk and tiny seed we have seen arranged and disposed tissues as wonderfully contrived and mechanisms as beautifully adapted to every condition of its life, as though it were the oldest cedar-tree or the largest oak of the forest.

# CONTRIBUTIONS TO THE HISTORY OF THE ROTIFERA, OR WHEEL ANIMALCULES.*

BY PHILIP HENRY GOSSE, F.R.S.

## I.

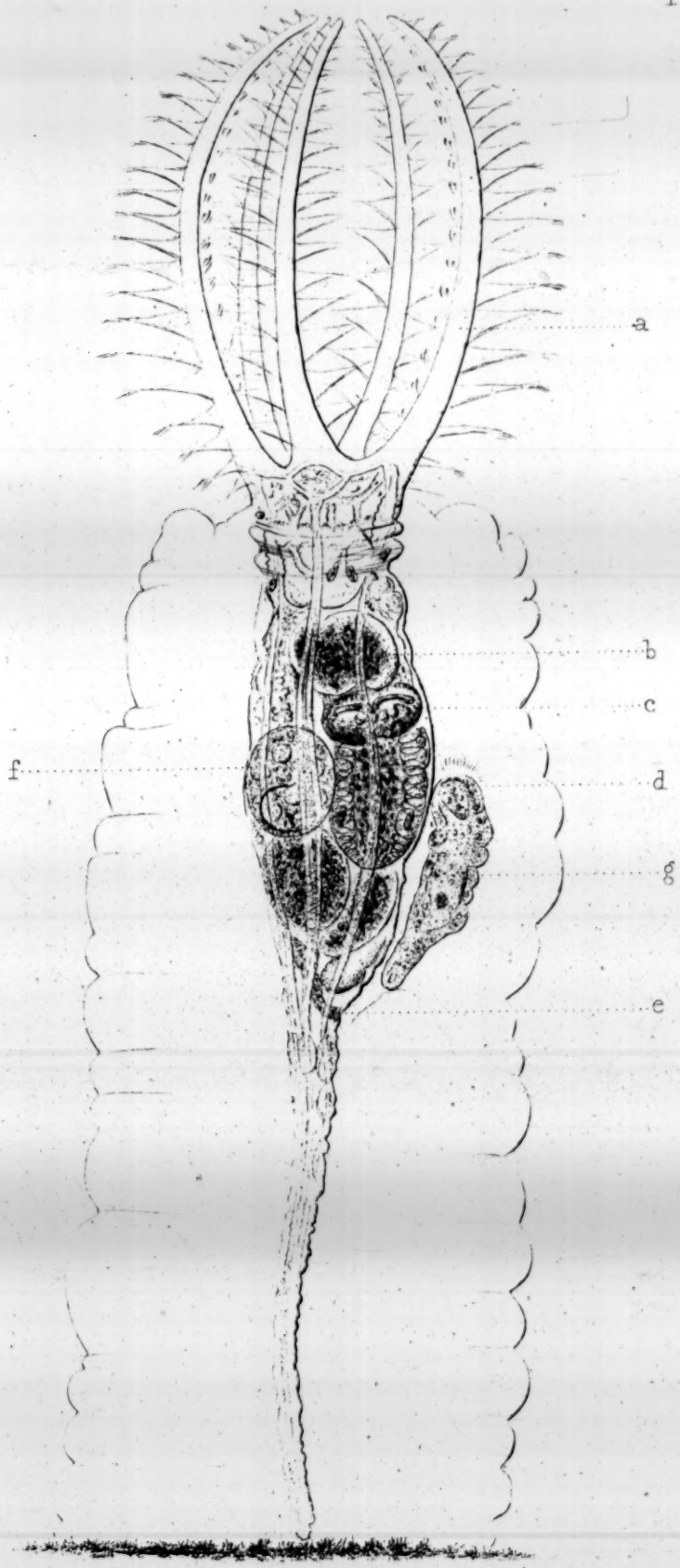
## THE CROWN ANIMALCULE

*(Stephanoceros Eichhornii).*

A LITTLE more than a dozen years ago, being then resident in London, I became a great frequenter of all the accessible collections of water in the vicinity of the metropolis. I had just purchased a microscope, and, looking with ignorant but interested curiosity at some drops of water from a neighbouring pool, was charmed with the varied forms and sprightly motions of the strange creatures that were disporting there. The result was the immediate determination to study and depict these—the creatures, namely, that were at that time included under a single group, and which had recently been opened up to the scientific world by Professor Ehrenberg, of Berlin, in his magnificent work, *Die Infusions-thierchen.* Since then it has been sadly pulled to pieces; like a block of granite, of which the constituent silex and feldspar and mica lie scattered in disintegrated granules, the great class *Infusoria,* so compact and firm as it appeared in the folio of the eminent Prussian microscopist, has dissolved under the storms of scientific controversy. One runs away with the *Rotatoria,* another with the *Desmideæ,* a third with the *Diatomaceæ:* the *Rhizopoda* get pickings; the *Annelida* put in a claim; and the remainder is so nibbled at, that we are fain to huddle away the few sheets of delicate engraving that are left in our hands, and hide them in a portfolio, for fear that Professor Agassiz should actually fulfil his threatening, and swallow up the whole.

Out of the great mass of strange forms thus brought under my notice, I soon selected the *Rotatoria,* or, as I prefer to call them, the ROTIFERA, as the objects of special attention and study; and for years thenceforth the examination, description,

* The papers of this series are chiefly intended for students somewhat advanced in science; but, so far as he has been able, the author has aimed so to simplify and arrange the matter as to convey intelligible information to such readers as have but little previous acquaintance with microscopical Natural History and Physiology.




The Crown Animalcule.

(Stephanoceros Eichhornii)

and delineation of these tiny creatures became the absorbing occupation of my entire leisure. So elegant are their outlines, so brilliantly translucent their texture, so complex and yet so patent their organisation, so curious their locomotive wheels, so unique their apparatus for mastication, so graceful, so vigorous, so fleet, and so marked with apparent intelligence their movements, so various their forms and types of structure, so readily attainable for study in almost every locality, and at all seasons of the year: that, as fact after fact and detail after detail of organisation and habit revealed itself to me, I often wondered that scarcely any one seemed to know anything about them beyond what might be picked up from turning over the pages of Ehrenberg at the soirées of the Microscopical, or from the abridged translation of his letterpress and the copies of his plates, which Pritchard had published.

I have said that this line of study made me familiar with most of the accessible collections of water in and around London. It is one recommendation of the class ROTIFERA as an object of research, that the species are so easily procurable, even to a resident in great cities. A moderate walk sufficed to put me in possession of some or other of the hundred and twenty species that I know to be British, all of which, with the exception of a dozen or so, I have found immediately around London.

Some of these waters were private. My very first essay was on a pond in the grounds of Mr. Samuel Berger, at Clapton, where the white lily was sitting like a queen amidst her round green leaves, on the still surface. The large *Euchlanis dilatata* swimming at large, several kinds of *Salpina* grubbing among the *Nitella* leaves, the pretty *Mastigocerca carinata*, with its rat-tail and its singular unsymmetrical dorsal keel, and the curious *Actinurus Neptunius*, remarkable for its extreme development in length, with other more familiar kinds, rewarded my search here. From a reservoir in the grounds of Mr. Alfred Rosling, at Camberwell, were taken *Monocerca stylata*, a new species, *Furcularia gracilis*, *Philodina roseola*, remarkable for the rosy hue with which its transparent tissues are tinged, *Notommata petromyzon*, with its conspicuous ruby eye, and *N. parasita*, eating out the interior of the majestic spheres of *Volvox globator*. A tank in the garden of Mr. B. Edwards, at Shoreditch, which, though in the midst of brick and mortar, has been celebrated for the treasures which it has yielded to microscopists for more than a century, has yielded me, among many other things of interest, the fine *Rotifer macrurus*, *Philodina aculeata*, so singularly studded with curved prickles like those of a rose-bush, and a new species of the very interesting genus, *Callidina*. A small reservoir in my own garden, and even a mere earthenware pan, filled with water and allowed to stand in the garden for some

time, have been very productive of good things. In the latter I have taken the pretty little house-builder, *Melicerta ringens*, on the finely-cut leaves of the water-crowfoot, as well as the still more elegant *Floscularia ornata*, and the exquisite *Limnias ceratophylli*; and, among the sediment, the long-legged *Dinocharis pocillum*, the thick-necked *Notommata collaris*, the tiny but active *Diglena catellina*, munching the half-decayed leaves and dropping its large eggs here and there, and the singular creature which I have described under the name of *Diglena (?) biraphis*.

Wayside ponds I found productive. There is one near the turnpike-gate at Lower Clapton, which I often visited, and always with encouraging success. Among other tenants, it contained *Euchlanis luna*, that form with the shell so singularly hollowed in front as to give it the shape of a crescent; the jumping *Polyarthra platyptera*, with its twelve jointed spears; several species of *Brachionus*, and an interesting little new genus, which I have called *Pompholyx*. A pond at Tottenham-green, well stocked with the *Lemna polyrhiza*, or many-rooted duckweed, has given me some prizes. The first phial of water I carried home from this pool proved very turbid when examined, and appeared to contain no animal life; but, after standing a week or two, it became clear, and was found to be densely swarming with the fine *Brachionus pala*, and another species which I have named *B. angularis*. A broad pond in front of Forest School, at Walthamstow, has always been very rich in ROTIFERA. Thence I first obtained that large and brilliantly translucent species, *Asplanchna Brightwellii*, so singular in its structure and economy, which first made known to us the difference between the males and the females in this class of animals. Here, too, I found the elegant *Œcistes crystallinus* living in its pellucid tube affixed to the herbage; *Brachionus amphiceros*, interesting for the clearness with which it has allowed me to understand some difficult points of structure; the noble *B. dorcas*, a new species, with very long anterior curving spines; and, swimming at large in the open water, the crystalline *Synchæta pectinata*, and the pretty little *Anurææ*, incapable of rest, because destitute of a foot. Hampstead Heath has always been a favourite resort with microscopists. A pond where horses are watered, and another just behind the Castle inn, are very productive of species; but tiny hollows on the Heath itself, many of them scarcely a yard in diameter, filled with a red-brown water strongly impregnated with iron, and completely dried up in hot weather, are unusually rich. In these, among many vegetable forms of much beauty and interest, I took the little *Stephanops*, with its arched helmet; the *Conochilos volvox*, forming spherical groups united by the feet; and an interesting

new form, which I have named *Sacculus viridis*. Ponds at Barking, at Greenwich, at Battersea, and other localities, have also contributed their quota to my observations.

Even dykes and ditches are not to be despised. A small ditch in a field at Shacklewell yielded me the lovely, but rather sluggish, *Pterodina patina*, and the curious *Triarthra mystacina*, which leaps vivaciously hither and thither, by means of its three long bristles,—both somewhat rare species. Another ditch in Parson's field, Stoke Newington, through which a tiny stream trickles, produced *Noteus quadricornis*, a fine, and by no means common species. In a dyke at the Isle of Dogs, I obtained *Hydatina senta*, that transparent species which Ehrenberg selected as his standard in describing the organisation of the class. Ditches at Stratford gave me *Chætonotus hystrix*, with *Scaridium longicaudum*, and *Notommata longiseta*, both remarkable for extraordinary longitude of limb; and an extremely curious form, very abnormal, as yet undescribed, but which I have called in MS. *Cochleare*. Then, again, in a dyke at Maidenhead—though this is rather beyond a walk from London—I found *Diglena grandis*, a very imposing species, highly predatory, and furnished with remarkable toothed jaws; and a new and fine species of *Salpina*,—*S. macracantha* (*MS.*). The reservoirs at Charing Cross, though not rich in species, have yielded me some of the free-swimming forms, as *Synchæta* and *Anuræa;* and among the conferva that grows along the stone-work of the margins, *Polyarthra* and *Furcularia forficula*, a rather good thing.

Collections of water of higher pretensions, such as the lakes in the public or private parks and pleasure-grounds, have not in general been more prolific in yield than these humbler pools and ditches. Yet these are the suitable places to search for those forms—in general of great beauty, and remarkable for their crystal clearness—which seldom or never rest, but are ever whirling with arrowy fleetness through the water. Such are the *Synchætæ*, which I have taken in some numbers in that fine piece of water known as the Black Sea, on Wandsworth Common, and the *Anurææ*, mostly containing small, but very brilliant species, which are abundant in the lake in Kew Gardens. The Serpentine has yielded me, besides these, *Asplanchna priodonta;* and I have taken this, together with *Notommata clavulata*, a very fine thing, in the water in Regent's Park. From the lake in Richmond Park, I have obtained *Stephanops muticus*, *Philodina megalotrocha*, and some species of *Rattulus*, together with some of the stationary and tube-dwelling kinds, as *Floscularia* and *Melicerta*, and the fine predatory *Diglena forcipata*. Finally, the water in front of Kensington Palace produced me the greatest treasure of all,

the rare and noble *Stephanoceros Eichhornii*. It was not till after years of search that I discovered this; but, in April, 1850, it occurred in considerable numbers adhering to the minutely pectinate leaves of *Myriophyllum*, pieces of which were floating on the surface, and were washed on shore by the little wavelets that the breeze threw up.

The next year, at the same season, I again obtained it at the same spot, but in less abundance. A year or two afterwards I tried again; but the pond had been cleaned out, the *Myriophyllum* had been carefully scraped to the shore and carted away, and not a *Stephanoceros* have I been able to find there from that day forward. I learn, however, that it has been taken in a pool at Highgate, and my kind friend, Mr. W. P. Bodkin, who furnishes me with the information, has promised to be on the look-out, in order to supply me with specimens. To the history of this fine species I now address myself.

*Stephanoceros* and *Floscularia* are the most abnormal genera of the class ROTIFERA. They are very closely allied *inter se*; but differ importantly from all other forms. I associate them into a family, marked by the following characters.

### FAMILY FLOSCULARIADÆ, OR THE FLOWER ANIMALCULES.

Animal free in infancy, permanently fixed in adult age, undergoing considerable change in form after birth, inhabiting a gelatinous tube which is excreted from the skin. Front produced into five lobes, beset with long ciliary setæ, or bristle-like filaments. Jaws seated far down in the abdominal cavity, not inclosed in a muscular bulb *(mastax)*. Foot long, wrinkled transversely, neither telescopic nor retractile.

### GENUS STEPHANOCEROS (EHRENBERG).

Frontal lobes long, slender, erect, convergent; ciliary setæ set around them in whorls. Jaws each of three teeth connected by a web.

There is but one well-established species, viz., *S. Eichhornii* (*Ehrenberg*). (See pl. iii.) This exquisitely elegant creature reaches the length of one-fifteenth of an inch, and is therefore distinctly visible to the unassisted eye. Ehrenberg can have seen only small specimens, as he gives one-third of a line as its ultimatum—one-thirty-sixth of an inch, and Leydig names half a line, or one-twenty-fourth of an inch; but I have seen several individuals of the dimensions I have named. The five lobes, which take the form of the petals of a flower in *Floscularia*, are here produced into long slender incurved arms, and the long setæ are arranged in verticils or whorls. They have not the length of those in *Floscularia*, but are still much longer

than Ehrenberg has figured them. I have traced them to a length equal to two-thirds of the greatest diameter of the body.* The points, however, run out to an extreme tenuity, and can only be perceived by the aid of delicate manipulation of the microscope. The five arms rise erect from the front, and converge to a rounded point after bulging outward, so as to present the figure of a tall crown or mitre (whence the generic name); but the points do not actually meet. It is rare to see a specimen with the arms spread, as Pritchard has figured (after Ehrenberg); I have once seen it in this condition; but I am persuaded that it is a mark of weakness or disease.

The front, at the base of the arms, forms a broad head, which is separated by a sort of neck from the body. This neck consists of two thickened collars, produced by deep annular infoldings of the skin. The body is irregularly cylindrical, or nearly so; but is generally swollen out in various parts by the full viscera, and the developing eggs. The dorsal side is the more swelling, and shows more distinctly the somewhat abrupt attenuation into the long and slender foot.† At its junction with the body, the foot is twice or thrice the diameter to which it diminishes at its lower extremity, where it is permanently attached to some foreign object, such as the leaf or stem of some submerged water-plant. Throughout its length this organ is much and irregularly wrinkled; it is capable of some degree of contraction, but it cannot be retracted within the body; it never shows any trace of those telescopic false joints which are so conspicuous in the *Philodinadæ*.

The Case.—The body is encased in a gelatinous envelope (pl. iii.), the general form of which is sub-cylindrical; but the outline is thrown into irregular transverse folds, apparently through sinking from its own weight. It is not a thin tube, as represented by Ehrenberg, with a roomy cavity, within which the animal lives, as *Melicerta* does; but is manifestly a thick and solid (if such a term is not a misnomer as applied to such a material) mass of gelatinous substance, with the exception of the space actually occupied by the body of the animal. From observations made upon the enveloping case, on occasions in which, for some reason or other, the animal voluntarily forsook it, it was apparent to me, that there was no organic connexion between the animal and its case, after the latter was once formed. The cavity left was nearly of the same form and dimensions as the body and foot, showing that it had been

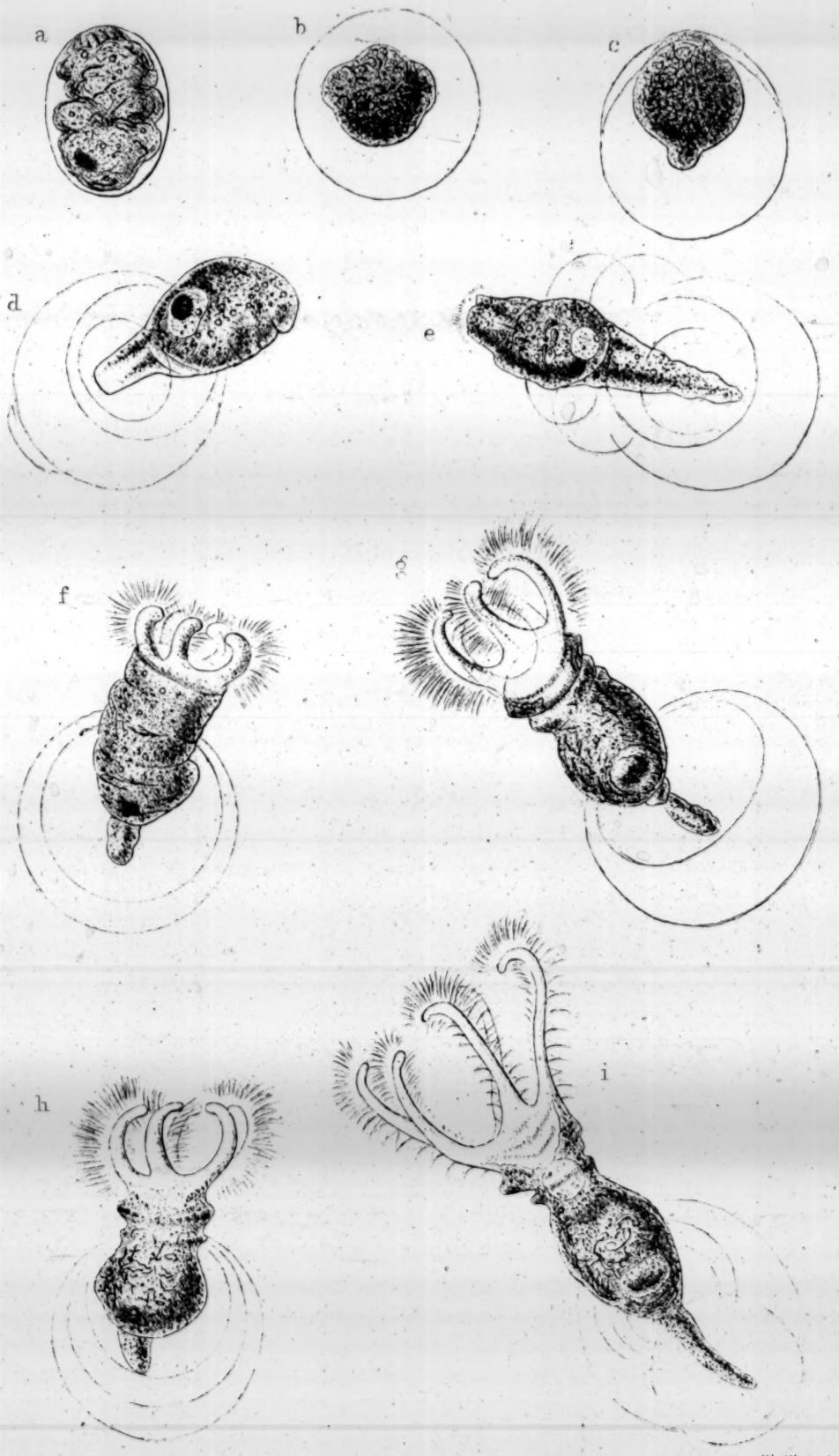
* Leydig makes them equal to the full diameter of the body.

† Leydig's figure (in Sieb. and Köll. Zeitschr., July, 1854) is, both in outline and in anatomical details, too diagram-like for life.

modelled upon these. During inhabitation the upper margin of the case is turned inwards; and when the animal suddenly and strongly contracts itself, the top of the case is somewhat drawn in after it. But this is not the result, as has been stated, of any adhesion of the margin to the animal, but simply that of the action of the water rushing into the vacuum suddenly produced by the downward retraction of the body, and carrying in with it the soft and flexible margin of the case.

The substance of which the case is composed is so delicately transparent that it is with some difficulty made apparent to the eye; indeed, only by its fine filmy outline. In old specimens, however, it acquires a brownish tinge, and much extraneous matter adheres to it. It is flexible, but not at all elastic; and apparently tough, without being viscid. Though, doubtless, a protection to the animal, yet, as with higher creatures, this advantage is not without its dangers. I once saw a *Stephanoceros* whose case had been accidentally bent down quite to a right angle, with many folds at the bend. The animal had no power to straighten it, but protruded, with its foot correspondingly bent. I have seen another, which, by some misadventure, had got one of its arms entangled in the substance of the margin of the case. It could not by all its efforts free the arm; and, after much apparent annoyance, during which this member evidently became diseased, the animal spontaneously forsook the case. Thus it remained, the foot (wrinkled up, indeed) projecting at a tangent, and the arm still fastened to the edge of the case by its ciliary setæ. Under these unnatural circumstances it soon died. While I am on these accidents, I may mention the example of another individual which voluntarily withdrew from its case. It was an operation of considerable labour and time; when the animal was clear of its tenement it slowly moved along by alternate elongations and contractions, but had no power of swimming. The foot presently wrinkled up into a distorted form, and the animal survived only a few hours. Doubtless, these forsakings are the expressions of the creature's uneasiness and an indication of disease. Such accidents should always be eagerly watched by the naturalist, as he frequently obtains an insight into structures and functions when these are modified by accident or disorder, such as no amount of patient investigation would have afforded him in the normal condition of his subject.

The summit of the case commonly reaches as far as the neck, or to the base of the arms of the animal when fully extended; and it is attached by its base, around the foot, to the support, as the leaves of *Myriophyllum* in my specimens. Thus the animal is completely enclosed to the height just named, and the only exit for the contents both of the ovary and the digestive




Crown Animalcule.

(Metamorphoses)

canal is at the top. In ejection the cloaca is much protruded and turned upwards; the fæces are discharged into the space between the body and the case-wall, and then gradually find their way upward and over the rim. The eggs are discharged into the same cavity, and there remain till they are hatched; the impressible substance of the gelatinous case yielding to make them temporary room; and the young when born struggle gradually upward and outward to liberty. But this I shall describe more in detail presently.

THE NUTRITIVE SYSTEM.—The internal organization of the *Stephanoceros* is complex, but the transparency of the tissues, at least when not occupied by the viscera, allows it to be well discerned, notwithstanding that the rays of light have to pass to the eye through various organs, the integuments, and the thick enveloping case.

The ciliated arms are carried commonly, as I have said, in an inarching form (plate iii. *a*), inclosing a considerable vaulted or somewhat ovate space. The setæ, or vibrating bristles, are arranged in whorls about fifteen or sixteen in number, but their closeness at the extreme point precludes the attainment of accuracy in counting. The whorls appear in perspective like pointed pencils, except on the arm which immediately fronts the eye, where they take the appearance of the beards of a feather. Those on the inside of the arms are seemingly much shorter than those on the outside, and form little brushes pointing upward.* Both arms and setæ are commonly held motionless; yet there is a manifest vortex in the inclosed area; for small *Infusoria* approaching are presently drawn in, and are driven about in the space. They can enter readily at all parts between the arms; but cannot get out, for if one approaches the arms from within it is seen instantly to be shot back towards the centre. At first I presumed this change of direction to be a spontaneous motion of the imprisoned animalcules, for they were active wayward Monads; but I perceived, after a while, a little inanimate atom have the same action; and, after some careful watching, I found that it was caused by the setæ; a minute, tremulous, and, as it were, spasmodic wave being seen to run along the nearest pencils at the instant. A slight jar of the stage or of the table will produce a similar wave along all the pencils simultaneously, as well as a momentary opening of the arm-crown. It is clear, then, that the setæ, crossing each other, serve as a living net, which admits the prey to enter without resistance, but, if touched from within,

* Leydig thinks that the setæ are planted in a granular stratum external to the cuticle, from which they are detached in bundles when subjected to slight pressure.

vibrates in such a way as to jerk the touching body with considerable force towards the centre of the contained area.

The presence of animalcules, especially if active and highly coloured, such as those of the genus *Microglena* or *Euglena*,* in some abundance in the surrounding water, gives rise to an instructive and entertaining spectacle. One by one they quickly accumulate in the living trap, and a dozen or twenty may often be seen swimming about in it, till one after another becomes engulphed in the deep cup-like mouth-funnel below the arms. When once they arrive here they rarely escape; but the whole contents of the arm-trap are often lost at once by the sudden retraction of the animal into its case, when all the prey are left behind free to escape. Hence it appears that the victims are retained within the arms by the vortical current, produced, probably, by the cilia which line the mouth-funnel, whose action is persistent during the extension of the animal; but that at the instant of retraction the ciliary vibration ceases, the vortical current is intermitted, and when the arms are drawn back the Monads remain where they were, there being in that instant nothing to prevent their passing between the tips of the arms.

But when once the prey passes down below the area in question into the mouth-funnel, which is formed by very contractile walls, a slight constriction takes place in the neck, which has the effect of forcing the Monad down to the mouth of a capacious crop or *proventriculus* (plate iii. *b*), which lies all across the upper part of the body. Here a sort of swallowing motion is seen, and the prey passes with a gulp down into the cavity.

This crop is formed of thick granular walls, which run up in high processes on the dorsal and ventral sides to the bases of the arms. Within the ventral one of these processes, at its upper extremity, is inclosed a minute clear oval body, perhaps glandular. There is an irregular row of similar but smaller bodies running round the collar. An opaque, ill-defined, cloudy mass is seen on each side, evidently resident within the walls of the crop, in no wise produced or affected by its contents.†

At the lower part and towards the dorsal side of this crop is placed the masticatory apparatus (plate iii. *c*), which consists of the ordinary jaws, evidently imbedded in the wall of the crop, working freely in its cavity without an enclosing *mastax*.‡

* These forms are considered by many observers to be "protophytes," or lowly organized plants.

† Dr. Leydig says the crop is furnished with four long bristles having hooked extremities, which appear, by their resistance to *liquor potassæ*, to be chitinous. These I have not detected.

‡ I have elsewhere given the name of *mastax* to the conspicuous muscular bulb, which in most ROTIFERA contains the jaws, and which answers to the true mouth in insects, &c. (See my memoir "On the Manducatory Apparatus in the Rotifera," in *Phil. Trans.* for 1856.)

Ehrenberg's figures of the apparatus in this species seem more than usually incorrect; it is but fair to add, however, that he admits his observation to be susceptible of doubt; and I can give my own testimony to the exceeding difficulty of obtaining satisfaction as to the real structure of these minute organs. According to my judgment, formed on many careful examinations, and that in many specimens, each of the two *mallei* or upper jaws consists of three curved diverging fingers, whose extremities are united by an indented membrane like the foot of a water-fowl.*

The *incus*, or lower pair of jaws, consists of two very moveable and widely-separated *rami*, shaped somewhat like a quarter of a globe, but much flattened, and each furnished with a lengthened process, which unites with its fellow to form the hinge, without a *fulcrum*. The *uncus* is connected with the *ramus* by an elastic ligament, by which means the latter is stretched open vigorously, while the teeth of the *malleus* act on the prey imprisoned in the crop.

Let us now follow the engulphed, but yet vigorous and active prey. The crop we will suppose to be nearly full of *Monads*, as I have seen it to the number of a hundred or more; then we perceive how ample is its capacity, for it descends, with the contained prey, far below the level of the jaws, while the individual Monads on which the action of the jaws has been passing, often return among their fellows. During life, and seen in action, the *incus*, or lower pair of jaws, takes the form of a long oval box, partially open across the middle, or that of a pair of slippers without quarters, placed heel to heel, so as to cross each other at that part. The two *mallei* resemble hands continually engaged in tearing apart the two sides of the box, or the toes of the slippers, by which action the aperture is alternately opened and closed, or rather made to recede and approach. The living contents of the crop come successively, but by no means regularly, within reach of the jaws, and are dragged into

* These constitute the *uncus*, the lower part of which forms a knob, inclosed in a muscular mass, which seems to answer to the ordinary *manubrium*. For a full explanation of these terms, and the organs to which they are applied, I must refer to the memoir cited in the preceding note. I may say here that a general idea of the apparatus of the mouth, which is very complex in this class, may be formed by supposing a pair of gardener's shears, the two handles of which are soldered into one, and then bent down at a right angle to the blades. Then imagine two claw-hammers to be placed, one on each side, working in the blades of the shears, to which each hammer is tied by an elastic cord. Inclose the whole in a great rounded vessel, and fasten the parts to the interior by muscular bands, leaving an orifice with a tube over the blades, and another beneath and behind them, and you have a rough model of a Rotifera's mouth. The shears are the lower jaws (*incus*), of which the blades are the *rami*, and the united handles the *fulcrum*. The hammers are the upper jaws (*mallei*), the claw-head of which is called the *uncus*, and the handle the *manubrium*. The inclosing vessel represents the *mastax*.

the aperture between the slippers. Here the *mallei* press upon the prey (suppose it an *Euglena*), with rapid and forceful forward movements, until they gradually drive it through the aperture downward. It is now free from the jaws, but does not pass into the stomach, but comes up around the sides of the apparatus again into the upper area of the crop, and whirling around with its companions, is presently again laid hold of by the jaws. I have seen the process go on many times in quick succession, upon the same individual *Euglena*, which seemed to sustain little damage from the ordeal; still, I suppose it is bruised at every turn, and thus the digestive action is facilitated, which seems to commence in the crop. That the prey is not crushed or its form seriously altered, is clearly perceived from the fæces which I have seen composed of the various species of *Monads*, &c., dead, indeed, and mixed with turbid green matter, but scarcely at all changed in outline. Larger prey is sometimes devoured, which cannot be forced through the aperture of the *incus;* thus, I have seen in the crop at once two *Coluri* (minute but highly-organised ROTIFERA), each of which is larger than the whole dental apparatus. The contents of their shells appeared to be nearly dissolved.

Digestion is completed in a globose stomach (plate iii. *d*), opening out of the crop below the jaws. This is a viscus of considerable capacity, of which the walls are thickened by being lined with large turgid cells, of a yellowish-green hue, which probably secrete bile, and pour it into the stomach-cavity while digestion is proceeding, thus performing the functions of a *liver*. The colouring matter of the food itself, when vivid green animalcules have been swallowed, may be seen running in among the cells, and diffusing itself through the thickened walls, leaving a hue which is visible after the food has passed away from the tubular centre. This latter, the true stomach, is very dilatable and contractile. It is separated—by a constriction, or perhaps by a proper diaphragm, sometimes very distinctly visible, but not always—from a globose intestine of nearly equal capacity, which communicates by a rather long *rectum*, ordinarily wrinkled longitudinally, but capable of great expansion, with the *cloaca*, which, as I have said, is very protrusile.* It

* Dr. Arlidge (Pritchard's "Infusoria" Ed. 4, p. 419) appears to confound the *intestine* with the *rectum* in the entire class. I find, however, no difficulty in distinguishing, in almost all *Rotifera*, a true intestine, situate below the true digesting stomach, from a *rectum*, a canal into which the fœcal pallet is discharged, and in which it occasionally remains a few minutes before it is expelled through the *cloaca*. By this last term I mean the common orifice of the digestive and the reproductive organs. Dr. Leydig considers, and I have come to the same conclusion, from the same premises, myself, that the complete and rapid manner in which the cloacal orifice closes, after the extrusion of the fœcal pellet, indicates the existence of a sphincter muscle there.

is situated on the dorsal aspect, at the point where the swelling trunk abruptly narrows to the origin of the foot (plate iii. *e*).

Thus we have followed the alimentary function from its commencement to its termination, and have found that an organisation, not a little elaborate and complex, is provided for this object.

The *Stephanoceros* is a voracious feeder. Ehrenberg saw large *Naviculæ* devoured by it, and in one individual a *Gonium pectorale*. He also saw that large infusory, *Stentor*, captured by it. Leydig witnessed the seizing of a great *Trachelium*, of various other *Infusoria*, and of the smaller *Rotifera*. I have myself seen the animal capture and devour scores of the *Infusoria* already named, in quick succession; and on one occasion observed one feeding on the young of *Floscularia digitata*, which were being hatched in considerable numbers in the same water.

The Reproductive Organs.—The reproductive organs occupy a very considerable portion of the bulk of the animal, and are sufficiently conspicuous at all times in the adult. Judging from analogy, I presume the *Stephanoceros* to be dicœcious; that is, that the males and females are distinct individuals; but I have not had any opportunity of detecting the male, nor, so far as I am aware, has any other observer. It will probably prove to be very unlike the female, and to have much the same form as the rudimentary young, before the development of the arms; to be destitute of masticatory and digestive organs, and to have a conspicuous mass of opaque white matter within the interior. These characters mark the male sex in the Rotifera generally.*

A bent or rolled ovary (plate iii. *f*) occupies the greater part of the ventral region of the female, within which eggs may generally be seen in various stages of development. I have seen as many as seven eggs developing at one time in one individual. The undeveloped portion consists of a clear sac, containing a viscid granular jelly, often slightly turbid, in which are placed trans-

* Dr. Leydig mentions having found among *Stephanoceri* that he was keeping for observation, a young animal possessing somewhat of the vermiform figure, with a proboscis-like head, furnished with four projecting arms. The pair of eyes were discernible. Two considerable tubular appendages projected from the trunk-like process of the head, which were ciliated at their extremities; the cilia which at birth are set round the tip of the foot had disappeared, but were very evident in the abdomen, near the sac containing the atoms, which he considers urinary. *The jaws had the ordinary structure.* He mentions having also occasionally found another variety, which, together with the figure of the adult, had five arms, but was without any apparent sexual organs, while the foot and body were entirely occupied with fat globules. If either of these abnormal forms was the male, I conjecture it was the latter; for the presence of the well-formed jaws in the former seems to exclude that form from the masculine sex. Still it was a very curious variation.

parent, highly refractive globules, separated by a space about equal to their own diameter. These are the eggs in their primary rudimentary stage. The nucleus may generally be discerned in each as a dull spot, surrounded by a bright space. One of these eggs enlarges rapidly, and gradually becomes more and more granular, until it is almost wholly opaque. It is now become well defined, and assumes the size and yolk form proper to the mature egg; but this shape is not constant, for being as yet destitute of a shell, the soft and yielding yolk is forced into ever-changing forms by the varying pressure of the digestive and other viscera in their proper motions, and in those communicated to them by the inflexions and contractions and elongations of the body.

Meanwhile, what is termed segmentation of the yolk takes place. The turbid, semi-opaque mass may be seen to be divided across the middle into two masses, each of these into two more; and so on, until the whole has become a mulberry-like mass of small cells. When this stage is reached, the dull opacity disappears, and is replaced by translucency, in which, however, we begin to discern a complex array of organs and viscera. The egg now contains a living embryo, whose movements within its enveloping integument as well as those of some of its organs, as for example, its jaws and its vibratile cilia, can be discerned with ever increasing distinctness. These motions are rendered more distinct,—are more readily determined to be proper to the embryo, and not communicated from the viscera of the parent,—by the circumstance that the envelope has now hardened to a firm, elastic, perfectly transparent shell, accurately elliptical in outline, from the internal wall of which we see the embryo recede at various points, waywardly and irregularly. Besides the organs I have named, two crimson specks may be seen near one extremity, and an opaque, undefined mass at the other. Both of these are seen to more advantage by using the direct light of the sun reflected from the stage of the microscope with a dark background. Then the red specks come out perfectly defined and of the richest vermilion hue, in the midst of the evanescent viscera, and the opaque posterior spot is seen to be quite white. The former are the eyes, which I shall speak of presently; the nature of the latter is not certain. Dr. Leydig supposes it to be an urinary concretion. It is very frequently seen in newly-hatched young ROTIFERA and in the males, I think, always (see plate iv. fig. *a*).

DEVELOPMENT OF THE EMBRYO.—Dr. Mantell was the first to observe the development of the young in *Stephanoceros;* and in his "Thoughts on Animalcules" he has recorded some interesting results of his investigations. I have myself verified

his observations for the most part, and have also extended them. I shall speak of what I have seen, except where my experience differs from his.

Between the most matured egg in the ovary and the cloacal orifice, lies the *oviduct*, a membranous tube of great expansibility, but when not in use longitudinally corrugated so as to occupy a very slender space. When quite ready, the egg is rapidly forced through the *oviduct*, and in a moment escapes through the protruded *cloaca* into the interstice between the body of the parent and the wall of the enveloping case, the gelatinous substance of which yields to the pressure of the intruding egg. Here it lies close to the cloacal orifice for a short time, varying from half an hour to several hours, at the end of which the young is hatched (plate iii. *g*). In one instance which I watched from the discharge of the egg to the hatching, the escape from the shell took up several minutes, and appeared a laborious task, reminding me of a caterpillar becoming a chrysalis. In general the liberated young slowly presses its way upward between the parent and its case, till it emerges at the margin; but the one that I have just mentioned made its way through the side of the case near the top, *boring*, as it were, a passage through the gelatinous substance by means of its vibrating *cilia;* the force of the ciliary currents apparently abrading the soft jelly atom by atom. Dr. Mantell mentions one which penetrated through the *bottom* of the case, a process which occupied three hours before it obtained freedom.

As soon as the young is free from the parental case, it swims vigorously away. Its length is now about one hundredth of an inch, or nearly one-sixth that of the adult (plate iii. *h*). Its form bears a rude resemblance to that of the parent, except that there is no trace of the coronal arms. The front is rounded, well set with strong vibratile cilia; the body is cylindrical, with many transverse corrugations, and a short thick foot is distinctly marked. The interior is occupied by a granular, often turbid, gelatinous flesh (*sarcode*), in which are placed many irregular bubbles (perhaps oil-bubbles), a few large bladder-like organs (the rudiments of the future viscera), traces of the five muscular bands, which subsequently will move the arms, the jaws, well formed and situate near the middle of the body, two brilliant red eyes near the front, and the opaque white urinary mass near the site of the *cloaca*.

Having swum giddily about for a while,—longer or shorter, from a few minutes to half an hour,—it becomes stationary, finding a resting-place for its foot. In the live-box of the microscope it generally affixes itself to one of the glass surfaces. The specimen which I have before mentioned, which was hatched under my eye, swam for ten minutes, and then became

permanently attached to the upper glass of the box, so that it was vertical in its position, with the foot next to the eye—a favourable aspect for observing the development of the case. It presently began to dilate its body, and in about five minutes from its attachment, I perceived a distinct filmy ring around it, perfectly circular, whose diameter was about twice that of its body (plate iv. fig. *b*). The little animal now began to lean over to one side, and the ring soon had another segment additional, leaning in the same direction (fig. *c*). The case, for such it was, looked like two broad hoops of glass, each swollen in the middle and set one on the other, but not quite concentrically, at least to the eye of the observer. It was manifest that it was produced by an excretion from the body, owing its form and size to the animal's moving round on the foot as on a pivot.

Three hours after the hatching, the form of the young animal was elongated and maggot-like (in another instance the young was eight hours in attaining this stage, while others in the same period had the arms well formed and furnished) (fig. *f*); the case having the appearance just described. No trace of the arms had as yet appeared. Night intervened, and the next morning, eleven hours after birth, the arms were beautifully formed, and of considerable length (fig. *g*); the mouth-funnel was well marked, and the general shape had become characteristic: the case had increased in dimensions. At eighteen and twenty-four hours, I found the arms becoming more and more perfect, and at thirty-six hours after birth it was a perfect little *Stephanoceros* (fig. *i*), the outline of the body well developed, the principal viscera, the collars, the mouth-funnel, the muscular crop, the jaws—all distinct; the ciliary setæ were now arranged in whorls of pencils, and vibrated on a slight jar; the "urinary" concretion behind remained, apparently within the intestine, as a sort of meconium. Indistinct traces of the opacities of the crop began to be discernible. In the animal at this age, the arms, which have attained the full proportional length, are carried much more divergent than usual, and it occasionally expands the coronal circle nearly to the extent figured by Ehrenberg in the adult.*

* I have not in any case seen the first budding of the arms from the rounded front. But Mantell mentions (and refers to his figures, which are, however, very indistinct) a cluster of four or five sub-conical papillæ, which in a young thirty-hours' old were perceptible "*within the body*," and which he supposes to have been "the rudimentary rotatory organs," in other phrase, the arms. Then, again, he mentions, eighty hours after birth, the young as bearing "five mammillated projections, fringed with cilia on the upper margin, evidently the rudiments of the tentacula." These latter were doubtless what he supposes them to have been, but in the former instance I have some suspicion that he merely saw the points of the brachial muscular bands (see the fig. of young in plate iii.). He figures a yet further development at

Circulation and Respiration.—The performance of these functions in the Rotifera is involved in a good deal of obscurity, as is shown by the diversity of opinions that have been expressed on them by the most careful and judicious observers. I have but little light on the subject derived from the *Stephanoceros*, and must, therefore, consider it with reference to the entire class.*

In almost all Rotifera there is seen towards the hinder extremity of the body, usually in contact with the cloaca, a bladder, which is often of conspicuous size, sometimes occupying half the volume of the abdominal cavity, or even more, as in some of the *Brachioni*. It is known as the *contractile bladder*. Under the eye of the attentive observer it is seen gradually and insensibly to be distended, until it attains its full dimensions, when, from its extreme clearness, its well-defined form (which is generally globular, or nearly so), and from the fact that it pushes aside the surrounding viscera, it is very conspicuous. No trace of corpuscles, moveable or stationary, can be discerned by the most careful scrutiny in its contents; yet no one can look on it without feeling quite assured that it is distended by a fluid. Over the walls, in some species, may be discerned numerous filaments irregularly ramifying and meandering.

When the bladder has attained its utmost degree of distension it suddenly contracts on all sides, and wrinkles up to a barely-perceptible point. The action does not occupy so much as a second; and as soon as it is accomplished the process of repletion goes on as gradually as before, and is followed by contraction in turn. The act of filling is called the *diastole*, the emptying the *systole*. The periods of contraction are generally uniform in the same individual, but sometimes they are very irregular.† The average interval may be perhaps set down at about fifteen seconds.

eighty-four hours, in which, however, they are not quite so advanced as mine in the earliest state in which I noticed them, at seven hours after birth (plate iv. *f*). The comparison of these data shows how extremely varying and uncertain are the periods of development in different individuals. They differ greatly, even when the conditions appear exactly alike; as in specimens hatched in the same live-box, in the same water, from the same brood, and on the same day.

* I must beg my reader's indulgence if my descriptions appear somewhat obscure. I have laboured to be as simple as possible; but the subject itself is intricate and difficult, and cannot be understood without some personal acquaintance with the objects themselves, as viewed with the microscope. The future papers of this series, with their figures, will help to make the subject much more intelligible.

† They recur most rapidly, so far as my experience goes, in the *Monocercadæ*; thus in *Monocerca rattus* the contractions are about thirteen per minute, and in *Mastigocerca carinata* I have counted twenty-five in the minute.

In *Stephanoceros* there is a rather small but clear bladder, (pl. iii.) placed behind the rectum, the filling of which I have repeatedly seen, but have never been able to catch clearly the contraction. Not that there is any doubt about the process, but I believe the animal invariably retracts its entire body at the moment of the *systole*, so that the process cannot be perceived in the confusion.

In connection with this curious organ there are others equally remarkable. Two bands are seen passing along longitudinally through the entire length of the trunk, one on each side, in most of the ROTIFERA.* They, for the most part, consist of threads, apparently tubular, hanging somewhat loosely, so as to form bends, which are invested with a thick corrugated envelope. Sometimes the tube forsakes the enveloping matter and passes straight along, while the coating forms a great bight. In some cases only one of these tubes can be seen on each side, but in others two, or even four, can be distinctly traced, loosely twisted together. The corrugated coating seems to consist largely of fatty matter, and may be intended for the protection of the delicate tubes. It is particularly copious in *Stephanoceros* (pl. iii.) These organs, which are called by pretty uniform agreement *respiratory tubes*, have never been satisfactorily traced to their anterior termination.†

Posteriorly, the extremities of the two tubes converge to the

* They are excellently-well seen in *Asplanchna*, in *Notommata clavulata*, in *N. aurita*, in *Euchlanis*, and in *Brachionus*.

† Professor Huxley, describing them in *Lacinularia*, says, on this point, "Arrived at the level of the pharyngeal bulb [*mastax*] each vessel divides into three branches: one passes over the pharynx [*buccal funnel*] and in front of the pharyngeal bulb, *and unites with its fellow on the opposite side*, while the other two pass, one inwards and the other outwards, in the space between the two layers of the trochal disc, and then *terminate as cæca*. Besides these, there sometimes seemed to be another branch just below the pancreatic sacs." Possibly some of these apparent branchings may have been only threads of connective tissue, whose purpose is to fasten the tubes to the walls of the abdominal cavity. I have never been able to trace any coalescence of the anterior extremities of these organs in any species. In *Brachionus* I am quite satisfied that each vessel terminates (whether by an *open* or *closed* end I do not know) in the lining-membrane of the lorica close to the lateral frontal spine; for the vigorous retractations of the moveable head-mass do not at all affect the relative positions of these vessels, nor throw them into curves. In *Euchlanis*, on the other hand, they terminate in the head-mass itself, and are not attached to the lorica. In *Stephanoceros* I have sometimes thought that there was such a connexion of the vessels as Mr. Huxley speaks of; for the curious little tremulous bags (which I shall presently describe) are found chiefly in the region of the neck, arranged around the second collar, but I have not been able to detect their attachment. I have seen *five* at once on this level, which seems inexplicable on the supposition of the supporting vessels passing only longitudinally on each side. I saw another tag on the dorsal side, a little below this level, and (in another individual) two at one level near the bottom of the stomach. (Pl. iii.)

surface of the contractile bladder, and seem to me to ramify over it, entering it by many mouths. One of those accidents which we can never command or control, but which are often highly instructive, gave me a little insight into the nature of the termination of these vessels. Examining a specimen of *Monocerca porcellus* which I had killed by means of the compressorium, the sudden and strong pressure severed the tortuous respiratory tubes and forced them out of the shell (*lorica*) hanging from the head-mass. They now appeared like crumpled cords, covered with close transverse lines, probably the effect of corrugation in contracting; and from their posterior regions *many short lateral branches were given off, the extremities of which had evidently been forcibly torn from their attachments.* I have never seen any tendency to a trumpet-like expansion of the posterior extremities of the tubes, at their entrance into the bladder, as Leydig implies, nor can I call this latter organ "a dilated state of the united ends of the two respiratory canals," even in *Stephanoceros.* Small as it is in this species it appears to be of the normal structure.

The most remarkable part of the whole apparatus, however, is the series of minute tremulous bodies which are attached to the respiratory tubes, much like the tags of rolled paper which are tied on to the pendent tail-string of a boy's kite. In all the larger ROTIFERA the watchful eye catches, from time to time, a tiny object that has a wavering motion, like the flickering of a flame. Often it cannot be detected at all; often one only, or two such objects are caught; but in favourable conditions we may generally discern four on each side (in *Asplanchna Brightwellii* more than a dozen) attached to each tube.

Ehrenberg was more happy in the function he ascribed to these minute organs, than in his physiological nomenclature generally. He says, "Their function is respiratory, and they are analogous to gills: the tremulous motion observable is that of the *laminæ* composing them." Here, however, he was misled by the deficiency of his instrument, and spoke too confidently from mere conjecture. Their structure is not laminated. They are evidently little ovate, or pear-shaped vessels, seated by a short foot-stalk on the respiratory tube and projecting into the body cavity so freely, that they are swayed hither and thither by every movement of the fluid with which the body is filled. The flickering motion is seen to be produced by a single cilium, which occupies the interior of the little tag, running through its centre lengthwise, attached near its free end, and pointing downward to its base. A rapid waving movement is communicated to the cilium, which is at pleasure intermitted; and so it is quite common to see only one or two tags flickering at

once. Sometimes the tags appear triangular or broadly pear-shaped, sometimes nearly cylindrical, or slightly elliptical.*

Such are the forms of the organs, so far as they can be determined. It remains to investigate the function and the *modus operandi*.

The first question is, what becomes of the contents of the contractile bladder at the systole? It is exceedingly difficult to trace the outflow of the fluid, and I have watched often and anxiously with the utmost care to detect this, in vain. Is it discharged into the cloaca, and so effused from the body? or is it poured into the respiratory tubes, and so passed into the system? Analogy would lead one to conclude the former to be the case; but, as I say, it is very difficult to see it. On one occasion, however, I saw this decisively. Carefully watching a specimen of *Notommata clavulata*, having previously mingled carmine with the water, I observed that the region of the rectum situate between the bladder and the cloacal orifice was distinctly puffed out at the instant of the contraction, and now and then I discerned, quite indubitably, that the minuter atoms of floating carmine were shot away by a discharged *jet d'eau*. Thus the excretory office of the bladder was decisively proved.

Whence, then, comes the fluid that is so discharged? Some have supposed that it is derived by direct and immediate percolation from without, through the cloaca.† Others believe that the sac is filled from the tortuous vessels. Dr. Leydig adopts this hypothesis. He believes that the water enters the general cavity from without, either by endosmose,‡ or by minute orifices hitherto undetected, and then mingles with the products of digestion, absorbed through the thin walls of

* These have been described as of two kinds. I find, however, that the variation depends on the aspect in which they are viewed. In a specimen of *Brachionus dorcas*, I casually obtained a very satisfactory view of one of the tags in the line of its long axis, when it was manifestly a flattened body. The triangular form is, then, that of the flat—the sub-cylindrical that of the edge. Cohn, correcting the error of Leydig, has also given this explanation.

† Mr. Dalrymple suggests that the bladder draws in water, and expels it again, by the cloacal orifice, and that it is by bringing the blood, by means of the ciliary movements of the tags, into immediate contact (the delicate membranous wall of the sac intervening) with the air of the water, that aëration or respiration is performed. M. Perty adopts this explanation. Dr. Cohn believes that he proved the existence of this incoming current, as well as of the outgoing one, in *Brachionus militaris*, a species peculiarly favourable for observation, on account of the enormous development of the bladder. On mingling colouring matter with the water, Cohn says he witnessed an inward current during each dilatation, and an outward one on each act of contraction, alternately.

‡ *Endosmose* is that law by which a thin fluid passes through a membrane to mingle with a denser fluid inclosed in it. (It is fully described in the paper on "The Lowest Forms of Life."—Ed.)

the intestine, to form the "chylaqueous fluid" of Dr. Williams,—the analogue of blood in the superior races. The effete water is then directed through the tags by their open ends, the vibrations of the inclosed cilium imparting the inward current to it, and so into the bladder. I quite believe this to be the true state of things; and therefore, that the respiratory tubes represent the kidneys, and that the bladder is a true urinary bladder. Thus in INSECTS, with which class I consider the ROTIFERA most closely allied, the kidneys exist in the form of long, often tortuous tubes, generally from four to eight in number, and often those of each side twisted loosely together, in which uric acid has actually been detected; while in some, as the water-beetles (*Dyticidæ*), there is a voluminous urinary bladder.

If this explanation be according to fact, it follows that the respiratory and urinary functions are in the closest relation with each other.

THE NERVOUS SYSTEM.—The nervous matter in this class exists in a remarkably concentrated and conspicuous form, constituting a cerebral mass, which, for its proportionate volume, may compare with the brain of the highest VERTEBRATA. One is amazed to find such an organ in the lowest type of the ARTICULATA, so compact, so well-defined, so large; and it is not without considerable hesitancy that we are induced to admit its right to a cerebral character. Yet there can be no reasonable doubt, that such it is. Its position in the anterior region of the animal, and usually with a dorsal aspect; its rounded outline, and compact figure; its greyish, granular texture; and, in particular, the connection with it of the eye, which is invariably seated like a wart upon it,—reveal its true character, which, so far as I know, has not been questioned by any observer.

Leydig does not recognize the brain in *Stephanoceros*;* yet I find it clear and indubitable, though small. (Pl. iii.) It is placed on the dorsal side, just beneath the second collar, behind the upper part of the crop, and immediately beneath the

* I do not mean that he has not described and figured the organ, but he does not recognize its function or homology. Under the title of "Special Organ," he has these words: "Immediately over the crop is found a structure, the value of which is unknown to me. It is a group of vesicles, clear as water, which together form a body ·024 line in diameter, which opens by a short but evident passage in the cuticle." This is certainly the brain. Its position, its conformity of structure with the brain in other ROTIFERA, and the seating of the red eye-point on its rotundity, which I have distinctly seen, leave no doubt on the point. The orifice he alludes to is paralleled by what I believe to be antennal orifices in *Asplanchna*, and by an actual antenna in *Notommata clavulata*, to which muscular and nervous threads go direct from the brain.

integument, which, in some specimens, makes a very distinct bulging or tumour to receive it. Indeed, the form of the organ, which is vertically pear-shaped or ovate, is always to be traced in the exterior outline. Its substance is delicately granular. I have not been able to trace any nerve-fibres given off from it; but around the frontal expansion, just at the base of the arms, goes a band of substance (pl. iii.), evidently very different from the muscular bands, and apparently not vascular, which is connected by branches with another broader band, that passes round at the upper collar; descending branches and threads go from this also, and appear to pass to the walls of the mouth-funnel and crop. These are probably nerves. I suspect there is a nerve-thread, which passes centrally through the entire length of each arm.*

On the upper part of the brain, and on its anterior (or ventral) surface, looking forward across the crop, is seated a minute but well-defined eye. By transmitted light it can scarcely be detected at all, and hence, probably, it has been usual to consider the organ as obliterated in infancy; but, under the rays of the sun, thrown on the object by means of a condenser, and reflected from it, the eye comes out sharp, distinct, and beautifully red, as if a globule of rich opaque vermilion had been placed among the clear pellucid flesh. I have no difficulty in finding it in adult specimens, by this mode of examination.

In the newly-hatched young there are *two* eye-spots. How these become changed into the single eye of the adult I do not know; I suspect by coalescence. I have, on more than one occasion, seen *three* eye-spots in a mature egg, of which one was minute, and under the others. I should have thought it an accidental monstrosity, but that I remarked it in two eggs. They were not prismatic spots, nor oil-bubbles, but globular specks, of opaque red, seen under sunlight.†

The Muscular System.—In its more prominent features, this is very distinct. A muscular band runs round the frontal disk, at the base of the arms, forming a low arch, or bow, in the swell of each arm-base. To this annular band are attached strong longitudinal bands, which run through the whole length of the body. These are associated in pairs, running side by side—five pairs in all,—each pair exactly corresponding to an arm in direction. Each pair begins to separate at the level of the upper collar; and, having been connected by a short

* See *infra*.

† There is no doubt at all that the crimson specks found on the brain in most Rotifera are real eyes. The *lens*, in some species, is distinctly discernible.

transverse band immediately after the commencement of the divarication, the individual muscle-bands join the annular band at remote points. Such seems the usual order, but it is not invariable; for in some specimens I have seen muscle-bands which seem to run down direct from the intervals of the arms, without uniting to form pairs. The longitudinal muscles pass through the foot, having, as I suspect, an insertion into the walls of the body near the origin of this member, by whose aid the foot can be thrown into strongly-marked transverse corrugations.

Besides the annular band mentioned, there is another which passes round the neck, unconnected with the longitudinal series, at the level of the first collar; and there are threads which are contractile, and therefore, I presume, muscular, which pass from side to side of the walls and processes of the mouth-funnel. I have not been able to trace any of the special muscles of the trunk, though doubtless such exist.

Diseases.—I have already alluded to the tendency of the *Stephanoceros* to disease. One curious malady it seems rather subject to. The foot attenuates, and soon appears to be dissolving in some parts. When the dissolution has extended through its thickness, the animal draws up the proximal portion that remains, and thus, having now no connexion with the gelatinous case, becomes free. The arms now become feeble, and can no longer maintain their beautiful mitre-like form, but expand widely; parts of the viscera also appear dissolving, and sometimes there is a protrusion of the intestines. Yet strong contractions of the body and vigorous working of the jaws still go on, twelve, eighteen, or even more hours after these symptoms have manifested themselves. At length the arms decay at the base, and become separate, when one part of each swells out into a large bladder, doubtless by the expansion of the gases formed in decomposition, and reveals an item of structure which is not discernible in health. Through the centre of the swollen part runs longitudinally a cord, which, from its granular appearance, and its resemblance to the bands that pass round the head, I judge to be nervous matter. The arms seem peculiarly liable to disorder. Often, towards the extremity of one, minute bubbles appear in the substance; these increase in number, and take the appearance of a congeries of minute black specks; soon that part of the arm sloughs off, and thus it is common to see a *Stephanoceros* with one or more arms reduced to stumps.

The arms are capable of being constricted, bent nearly at an angle, or drawn up, with close-set wrinkles, into a very short space. This last process sometimes occurs with one arm alone;

sometimes with all at once. One in my possession, from a perfect condition, so shortened all the arms (not, however, while under my eye), that they were reduced to the merest rudiments or tubercles, retaining a few of the pencils of setæ; and though these subsequently lengthened a very little, they did not become normal again.

Of an individual which I had found in health, the foot, the next day, separated itself from its attachment by the sloughing of a portion, leaving a ragged edge. The body did not withdraw from the case. The foot went on to dissolve away upwards, in a very ragged form: about the third day the arms became shrunken, flat, and distorted. The setæ were now seen to be of great length; they vibrated still when jarred, and now and then spontaneously. Under these circumstances the nature of the vibration was far more discernible than in health. I could now distinctly see that each seta bent laterally, and then straightened itself like a whip smacked; the flexion was performed suddenly, the extension gradually. The flexion appeared to be from south to west.*

The animal is not difficult to keep alive in jars of fresh water, exposed to the light, but guarded, of course, from the hottest rays of the sun. The water-plants on which it lives attached are essential; but these need not be rooted. Fragments of *Myriophyllum*, *Ceratophyllum*, *Nitella*, *Potamogeton*, &c., may be detached, and will continue to live and grow while submerged. I have kept *Stephanoceros* for five or six weeks.

I do not know any other localities in the British Isles for the species than those which I have mentioned. But it is widely spread on the continent. Eichhorn found it at Dantzig, exactly a century ago, and figured it in 1775. Ehrenberg rediscovered it near Berlin in 1831, and afterwards saw it on several occasions. Weisse met with it once at St. Petersburg. Perty's *Stephanoceros glacialis*, found by him in Switzerland (in the Todtensee, on the Grimselhöhe), was probably only a deformed and diseased specimen of *S. Eichhornii*.

Such is the history, so far as I have unravelled it, of the largest, the rarest, and the most elegant species of the class ROTIFERA. An exquisite form it is, and one whose structure

* I use this mode of indicating circular motion, because it is precise: we have only to suppose the plane of the circle to be horizontal, and no mistake can possibly be made. The ordinary phrase, "from left to right," or *vice versâ*, is indefinite and ambiguous, because "right" and "left" are *opposite* points of a circle, and motion from one to the other may be in opposite directions. If to describe the sun's apparent motion as "from left to right" is intelligible with us, it is only because a portion of the circle is beneath the horizon. At the poles it would be quite ambiguous.

and habits will, I have no doubt, abundantly repay investigation by careful observers with good instruments, as there are many points in its economy on which we need further light.

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## EXPLANATION OF THE ILLUSTRATIONS.

PLATE III. represents an adult female *Stephanoceros Eichhornii*, magnified one hundred diameters. A young one, just hatched, is seen within the parental case, working its way upward to liberty.

PLATE IV.—Metamorphosis and development of the same. Fig. *a*, The egg just ready for hatching: *b*, The young, fifteen minutes after birth, permanently attached, with the first elements of the case deposited: *c*, The same, twenty-five minutes old, with a new segment to the case: *d*, Another individual, four hours old: *e*, One, three hours old. The development in these two is at about the same point, but that of the case in *e*, though the younger, is rather the more advanced: *f*, *g*, *h*, Intermediate conditions, from six to twelve hours old: *i*, The adult form perfectly developed, at thirty-six hours after birth. Figs. *b*, *c*, *e*, *g*, and *i*, represent the same individual. In each figure, the foot of the animal must be understood to be adherent to the *farther* surface of a plate of glass, and the case to be attached around it, so that both animal and case project *from the eye*.

For fuller information on all that has been published concerning this species, the reader is referred to Ehrenberg's Memoir, in the "Berlin Transactions" for 1831, and his "Infusions-thierchen;" to Dr. Mantell's "Thoughts on Animalcules," and to Dr. Franz Leydig's admirable Memoir on the ROTIFERA, in Siebold and Kölliker's "Zeitschrift," for July, 1854. The new edition of Pritchard's "Infusoria" (1861) contains a valuable summary of the researches of the continental *savans* on the whole class, including, of course, the present species.

# THE LOWEST FORMS OF LIFE.

## VEGETABLE LIFE—THE "PROTOPHYTA," OR "FIRST PLANTS."

BY THE EDITOR.

THOSE who have never witnessed the beauties of the microscopical world can form no conception of the astonishment and delight afforded by the first glance into the magic tube.

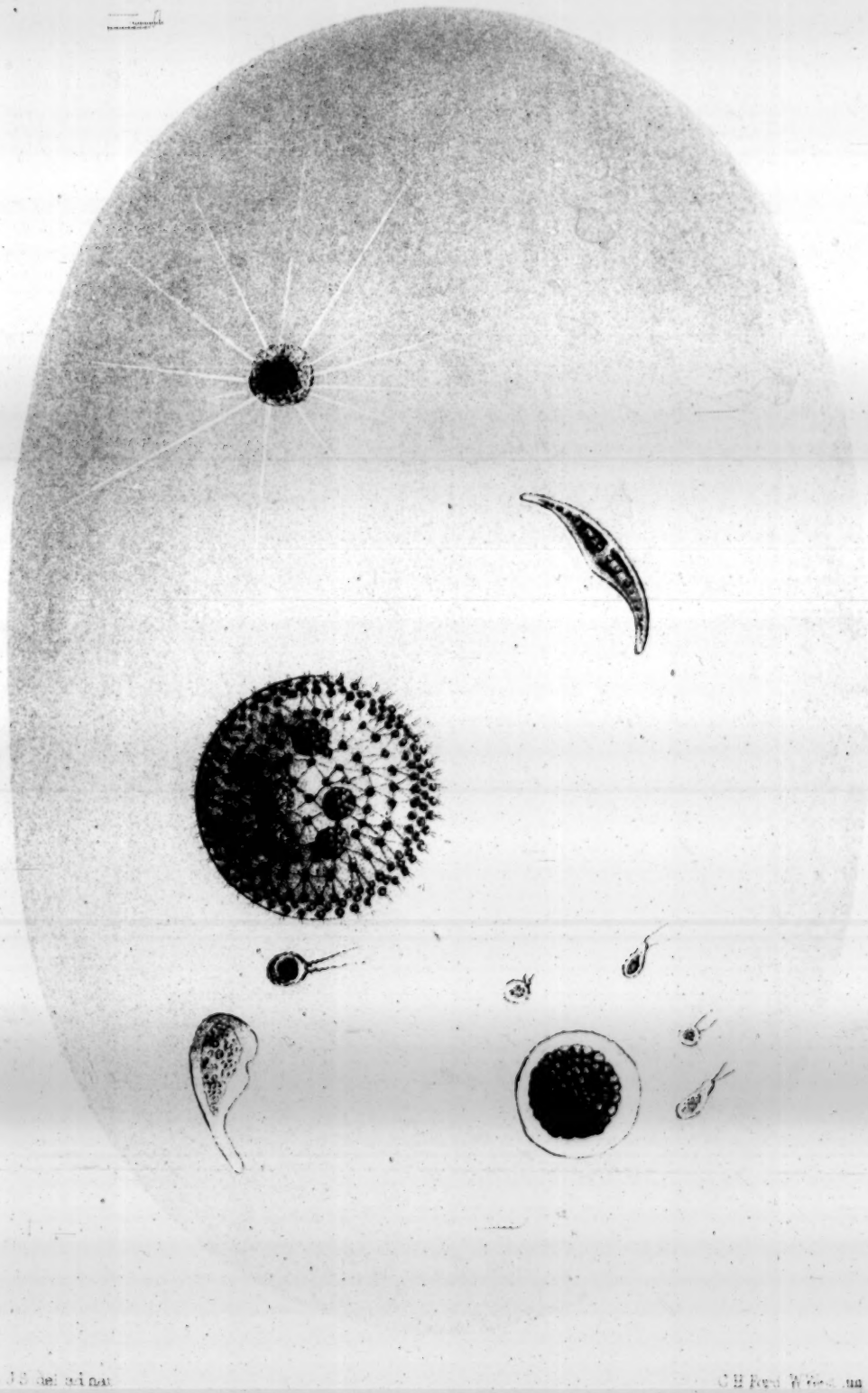
It is nearly ten years since I experienced this pleasure, but I recollect the circumstance almost as though it were yesterday.

My instrument had cost me about ten shillings, and the substance that I first examined with it was a little of the green scum from a water-cistern behind my house. To find in this suspicious-looking fluid myriads of bright green globules sailing about swiftly in all directions, was as great a surprise to me as it was afterwards to hear that each of these moving specks was a living *plant*, endowed with the capability of moving from place to place in search of suitable nourishment; and that, if I had looked carefully, similar organisms possessing *animal* life would also have been visible. It is, as just stated, nearly ten years since I peered into the microscope; and if the novelty has somewhat abated with increased experience, the loss has been counterbalanced by the gratification with which I observe the delight of others when they first inspect similar objects through the more powerful and complicated instrument that I now possess.

During the hot weather last June we had on a visit with us a young lady who asked me on more than one occasion to "show her something under the microscope;" and having postponed the fulfilment of her wish until the warm weather had called into life most of the denizens of the pools, I one morning sallied forth with my ring-net and pocket lens in search of something interesting, and on my return fixed the same evening for the exhibition.

As the time approached, conjectures multiplied as to the character of the "animals" that would be found in the water; and, immediately after tea, I retired to my study, to investigate before exhibiting the contents of my bottle.

This did not occupy much time, for my fishing expedition had



The Lowest Forms of Life

been most successful, and I had little difficulty in preparing a slide that contained a variety of microscopical forms.

Displaying these to the best advantage, I called our young visitor, whose curiosity, I was told, had meanwhile been finding vent in more conjectures, and who soon arrived, in company with one or two members of my family.

In order that the reader may be better able to understand what followed, I have annexed a sketch of some of the forms as they appeared in the instrument, but must add that it gives a very inadequate idea of the scene that presented itself (pl. v.). The brilliant colours of the objects, chiefly of the brightest green, their varied movements, and the blaze of liquid light in which they floated—all are gone, and only the inanimate likenesses are here pourtrayed.

"Well, what do you see?" I asked, as she bent her head, astonished, over the instrument.

"See? why, this might be the secret haunt of some bright fairy, whose magic influence is at work down there!"

"And can you recognise no power above a fairy's in that scene of hidden wonders?" I remarked.

"True, true," said she; "but what are all these living shapes? Is this a microscope, or telescope? Why, surely these must be the heavenly bodies!"

She raised her head to look again at the slide, on which, however, she could detect nothing beyond the drop of water covered with a thin square piece of glass.

"Look once more into the instrument before the objects leave the field; for I may not be able to show them to you so favourably grouped again."

"Well, I see a little globe, green and bright as our own beautiful world, revolving slowly on its axis; but its brilliant hue is here derived from countless emeralds that stud its surface; and, bless me! she is indeed a 'mother earth,' for I see several more such globes revolving within her body! And yonder is the moon in her first quarter; and below, Jupiter, with his four satellites;—but, they are flown—no, here they are again, whisking about as gaily as ever.

"And that must be the sun, that pale yellow sphere with diverging rays.

"But what is this amongst the heavenly bodies? 'Tis a double cross!"

All present appeared to enjoy her surprise, but none more than I; and I could not help laughing at each new exclamation of delight.

"Now," I remarked, after her surprise had somewhat abated, "I must to some extent break the charm. The beautiful revolving globe is *Volvox globator* (only the Latin designa-

tion of a 'rolling sphere'). It was formerly known as the 'globe animalcule;' 'tis, however, not an animalcule at all, but one of the lowest forms of vegetable life."

"What!" she exclaimed; "a plant? Why, it lives—it moves."

"All plants live, in one sense, and many of the lowest possess the power of locomotion. There are some living forms to which naturalists have not yet been able to assign a definite position, either in the animal or vegetable kingdom; but this one is now generally recognized as a true plant. So also your 'moon in her first quarter;' it is *Closterium moniliferum*. I am sorry the name is not more homely; but it means the moniliferous, or necklace-shaped Closterium (from the fancied resemblance between the row of globules within it, and a necklace). Another species of Closterium is called *lunula*, but it does not resemble the moon as much as this one.

"The object you called Jupiter, the smaller globe, is a young Volvox in process of development—also a plant, therefore; and its 'satellites' are the moving germs of another lowly plant, *Protococcus viridis*, whose myriads of myriads impart to the surface of the rain-water in cisterns that green tinge which you must frequently have noticed. They subsequently lose their power of locomotion, and, settling down at the bottom of the vessel, they assume a reddish hue.

"The double cross, *Staurastrum gracile*, the graceful Staurastrum,* is another of the same order of plants† as Closterium; but your 'Sun,' which is actually designated *Actinophrys Sol* (the radiating sun), from its resemblance to the source of light, is one of the lowest known forms of *animal* existence.

"One of the most remarkable objects in the field has, however, escaped your notice, and that is the insignificant slimy-looking mass a little to the left of Volvox."

"What! do you mean that which resembles the map of South America in miniature, and seems to be constantly changing its shape?"

"Precisely so; and I am glad you have descended from the skies, and can, at length, find something on earth with which to compare it, even though it be a continent!

"It *does* continually change its shape, and hence its name *Amœba*, from a Greek word denoting that it alternates; but I must beg you to let it rest at present, and if, moreover, you will put aside the microscope, I will endeavour to describe,

* This name is derived from two Greek words, signifying a "cross" and a "star."

† The Desmidiaceæ. (See Ralf's "British Desmidieæ.")

as popularly as I am able, some of those lowly forms of vegetable existence that have so greatly excited your admiration."

My young visitor expressed her readiness to give me her attention; and, in the hope that the reader will do the same, I venture to proceed with the account of our conversation.

"To begin at the beginning. You are of course aware of the difference which exists between a *physical* and a *vital* force—the power that causes an apple to fall to the ground, as distinguished from that which causes it to grow; and you doubtless know that when we see in an organized fabric a vital energy at work, operating irrespective of the physical laws, or even in opposition to them, we call that energy '*life*.'

Thus, for example, if a tree were to lose one of its branches by the blow of an axe, the *physical* force that we call attraction would cause it to fall heavily to the earth; but if, through the *vital* properties of the tree, a fresh branch were put forth near the stump of the old one, it would in all probability grow in the opposite direction to that in which the latter fell: the *vital* power of growth being in this instance superior to the physical power of attraction.

Now, although these forces are apparently distinct in their nature, yet they are closely interlinked one with another, and every day we find a nearer and nearer relationship, if I may so call it, between them.*

However interesting this subject may be, I cannot dwell upon it this evening, and must now tell you that the force or energy termed 'life,' is, practically speaking, first called into operation in a minute cell, or capsule; and that not only all plants, but also the bodies of all animals, are made up of an assemblage of such cells, more or less modified in form and character.

I say 'practically speaking,' because life may be found in bodies that do not even lay claim to the designation of a cell, as that Amœba, for example, which you found to be little else than a speck of slime; and yet *it* possesses a vital power sufficient to enable it to digest its food and grow.

However, even scientific men are satisfied to regard the 'cell' as the lowest form of life; and those cells that possess animal properties they have grouped together under the title of PROTOZOA, from two Greek words signifying the 'first animals;' whilst those exhibiting the characteristics of the vegetable kingdom they call PROTOPHYTA, or the 'first plants.' The little objects that you compared to Jupiter's satellites, which moved so

* See Carpenter's "Address on the Correlation of Physical and Vital Forces," delivered at the Royal Institution of Great Britain.

rapidly about the smaller Volvox, were four such cells endowed with the power of locomotion, in order that they might move about in search of their proper *pabulum*, the scientific word implying food, but a more appropriate one than the latter in this case, for we can hardly say their 'food,' inasmuch as they are, as I have already told you, not animals but plants. Before our investigations are complete, I dare say I shall have an opportunity of showing you similar forms possessing the properties of animals."

"But tell me, pray," my young pupil asked, interrupting me, "by what means are you able to distinguish between a plant and an animal, if both possess life and motion? and both, in this instance at least, consist of a single cell. If you place before me a man and a tree, I have various means of distinguishing which is animal and which vegetable; but in this case I confess I should be puzzled to know one from the other."

"Ay; and wiser persons than you or I are puzzled every day with the same problem. As I told you before, there is a vast number of living forms whose nature, so far as its being animal or vegetable, is still undecided; and I should have great difficulty in referring you to any work on Natural History that would enlighten you in this respect. One author will tell you that the distinction consists in the animal possessing a stomach for the digestion of food, whilst the plant has no such cavity. Another, that *sensation* distinguishes the animal from the plant; a third, that in vegetable substances we always find *starch*, but not in animal forms; a fourth will say animals inhale oxygen and exhale carbon, whilst in the vegetable kingdom the reverse is the case; and a fifth will cut the Gordian knot by boldly asserting that there is no appreciable difference between the lowest forms of animal and vegetable existence.

But now to what 'new' conclusion do you think naturalists are hastening in this respect?

Simply this. Animals are nourished by organized substances, either alive or in a state of *partial decomposition*, whilst plants derive their sustenance from *in*organic substances, such as phosphate of lime, ammonia, water, &c. This definition of the difference between the two classes of living objects is not quite satisfactory, but it is, I think, the best that you will find in the present state of our knowledge. And, curiously enough, it accords with the oldest theories on the subject; for, as plants were first created and then animals, plants must have derived their support, as they do now, from inorganic substances—carbon, water, nitrogen, &c.—which they extract from the earth and atmosphere; whilst animals feed upon organized compounds, which they ingest and work up into their own substance, either in stomachs perfectly formed and

constant, or in imperfect temporary cavities framed for the purpose.

And this distinction holds good in the perfectly-formed animal and vegetable, such as the man and the tree, as well as in the lowest known types of either kingdom; so you see we are reminded at every step of the unity of those laws by which nature is controlled.

Bearing in mind that it derives the nutriment that ministers to its growth from the inorganic constituents of the water, you will, of course, see that our little vegetable cell must not remain long in one place, lest it should exhaust the supply around it, and it is therefore furnished with one or more little whip- or hair-like members, by means of which it moves rapidly from place to place. If you had carefully examined the little forms that moved about the Volvox, you would have perceived these members of locomotion. (Pl. v. and pl. vi. fig. 1.)

The '*cilia*' (as these hair-like fibres have been very appropriately called, from the Latin word *cilium*, an 'eyelash') have an inherent contractile power, similar to that of the sensitive plant, and so long as there is vitality in them they are in constant motion. You may, perhaps, be surprised when I tell you that we have vast numbers of them at work in various parts of our bodies, which, unconsciously to ourselves, keep certain of the fluids in active circulation; and in the living oyster they may be seen to perfection; so, you see, they are common to animals as well as plants. But to return to our little living cell.

If there is any subject into which scientific men have imported a terrible array of hard words, it is into the history of this simple little object; and if I were to begin to discourse learnedly to you about 'primordial utricles,' 'cytoblasts,' 'endoplasts,' and 'protoplasma,' I am sure you would all be fast asleep before I had finished my explanation of the meaning of one of these terms in connection with the anatomy of a vegetable cell.

Without at all sacrificing to scientific accuracy, however, I am fortunately able to borrow a very clear and simple description of this object from a work recently published in connection with the microscope.* It is '*a closed sac, composed of an (originally) imperforate membrane formed of the chemical substance called cellulose, this membrane inclosing fluid contents so long as the cell retains its vitality.*'"

"That may be a very clear and simple description of a vegetable cell to you or any other scientific student," said my young pupil, "and I *believe* that *I* understand its meaning;

* Griffith and Henfrey's "Micrographic Dictionary," page 126, article "Cell." Van Voorst. 1860.

but if you could compare it to some object that has come under our observation, I think you might render it still more comprehensible to us all."

"Well," I continued, after a little consideration, "I will endeavour to be more familiar in my exposition, and will give you a simile, not a very pleasant one perhaps, but one that will enable you to form a clear conception of its structure. You have seen those little gelatinous capsules containing castor-oil, sold by druggists, have you not? Suppose the gelatinous husk or shell of one of these to be thick, soft, transparent, and very elastic; the contained castor-oil to be more viscid than it is, and floating in it a number of little green granules; lastly, imagine the whole capsule to be globular, and so small as to be invisible to the naked eye;—you will then be picturing to yourself that wonderful little mechanism, of which the secret spring is 'life,' the lowest living thing that has the power of growth and reproduction." (Pl. vi. fig. 2.)

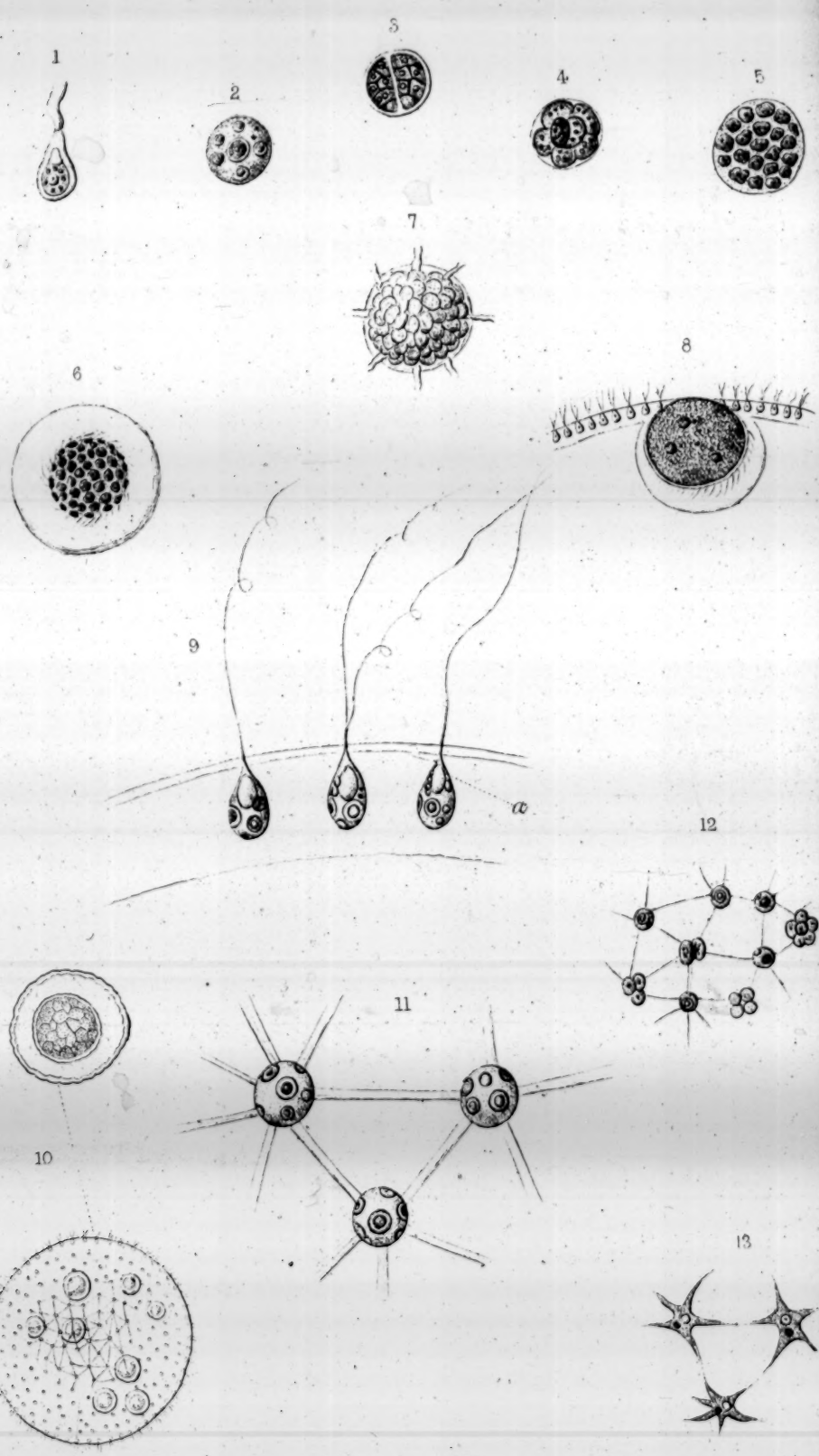
"But you just now described one of these cells as 'a closed imperforate sac;' how, then, can it grow and reproduce? indeed, how does it imbibe nourishment?"

"I will answer the last question first. If you fill a bladder with water, are you not aware that the moisture will pass through it, although it is closed?"

"Certainly; and that reminds me that I have often been surprised at the manner in which water exudes through those earthenware 'water-coolers,' giving to the material of which they are made a deeper tinge than when it is dry."

"Precisely so," I continued; "and this is called *exosmosis*, from two Greek words, that signify, 'an impulsion outwards.' If, however, the bladder or earthenware bottle were empty, and you immersed it in water, the moisture would in like manner penetrate into the interior, and this is called *endosmosis*, or 'impulsion inwards;' but we may go still further. 'If two fluids of unequal densities are separated by an animal or vegetable membrane, the denser will attract the less dense through the membrane that divides them. This property is called *endosmose*, when the attraction is from the outside to the inside; and *exosmose*, when it operates from the inside to the outside of the body acted upon.'* This is the principle—now for its application. The vegetable cell, as I told you, contains a dense fluid, and so it attracts the moisture from without through its capsule or cell-wall, draws from it the materials necessary for its growth (ammonia, carbonic acid, &c.), and gives out oxygen through the same medium. This is the mode in which a cell is nourished; and, although it would be too great a digression

* Brande.




J B Hicks del. Dixon Webb sc.

W. West, imp.

to explain how and wherefore, I may add, that upon this principle, too, the substances that we eat and drink are ultimately distributed through our bodies; for it is by means of simple cells that they are taken up and conveyed into the blood: so you see, that small and apparently insignificant organisms often perform very important offices.

"So much for the mode in which the cell is nourished: now a word as to its growth and reproduction, and then, I think, you will have made sufficient progress in vegetable physiology to enable you at least to understand the history of *Volvox globator*.

"Immediately within the capsule, or covering of the cell, the little granules are formed, which, I told you, float about in the fluid contents of the cell. These increase in number, and the external gelatinous case becomes distended, and adapts itself to the growing substance within. The latter soon divides into two parts, either in a direct line across the cell (pl. vi. fig. 3), or obliquely; and these two parts, which are in reality two new cells, burst the outer coat, and swim away (furnished with two cilia for the purpose) to be nourished, subdivided, and reproduced in the same manner as the parent cell. There are other stages into which they pass; but this is the first and essential process by which they are multiplied with incredible rapidity.

The chief difference between the simple little cell, that I have been describing to you, and *Volvox globator* (pl. v. large globe), the 'rolling globe,' is that the latter is an aggregation or assemblage of the former, which, instead of escaping after they have subdivided, *remain permanently attached to one another*, and form that beautiful little globe which has so greatly excited your admiration this evening. You will recollect that it presented the appearance of a crystal ball studded all over with objects resembling emeralds, connected together by delicate lines, and within it there were eight smaller globes, of a deep green colour. A smaller globe also, similar to those within the larger one, you will remember, was revolving a little to the right of the latter,* and I will now endeavour to explain to you the relationship existing between the globes.

First of all, a simple vegetable cell filled with green granules (pl. vi. fig. 2, 3) undergoes the process of subdivision into two parts, as already described. Then, instead of these two parts becoming detached from one another, each again subdivides, and so the process of 'segmentation,' as it is called, goes on (pl. vi. figs. 4, 5, 6, 7) until the whole mass of cells assumes the appearance of a mulberry. Unlike the mulberry, however, it is *hollow*, and is surrounded by a transparent gelatinous capsule (pl. vi.

* The reader should refer to the plate when necessary.

figs. 6, 7) resembling that of the original cell before subdivision commenced. Here and there we find 'cilia' (the little locomotive fibres already described) protruding through the outer gelatinous coat; and these cilia, which belong to some of the divided cells, cause the whole mass to revolve by their simultaneous movements. They do not, however, make their appearance until growth has considerably advanced.

When the process of segmentation is complete, and as many of the young cells (which are called 'zoospores,'* or 'gonidia') are present in the mulberry mass as are afterwards found upon the mature Volvox, then the transparent enveloping membrane begins to expand, and the green gonidia spread wider and wider apart, but remain connected together by thread-like filaments, which become thinner and thinner as the distance between the cells increases, until at length they are hardly traceable even under a high microscopic power; and then the Volvox presents the appearance of a beautiful crystal globe studded all over with ciliated cells or gonidia (pl. v.).

You may easily understand this mode of development if you picture to yourself one of those hollow india-rubber balls protected by a network, that are used as toys by children; and suppose the network on one of these balls to be elastic, and so completely covered with green beads that the ball is rendered invisible. Now, imagine the ball to be gradually distended with air, and the beads thus stretched farther and farther apart, and until the *network* is lost to view, and only the beads are perceptible, studded all over the thin distended globe. This will enable you to understand the circumstances under which Volvox is developed, and assumes its beautiful appearance.

To revert to our living Volvox, however, the gonidia, or green cells, which *appear* to be upon its surface, are in reality *imbedded* in the gelatinous membrane that forms the globe, the cilia alone protruding through the latter (pl. vi. fig. 9); and it is these gonidia that undergo subdivision or segmentation in the manner described, forming the smaller globes (the young Volvoces, in fact) that roll about within the larger one; for they grow *inwards* (pl. vi. fig. 8), and as soon as they have attained a certain growth, they become detached and fall into the cavity (pl. v. larger globe).

The number of the smaller globes is usually eight; and as these soon become too large for the parent to hold them, the latter bursts and sets them free, after which they move about in the watery element, and in like manner give birth to similar forms. But what is most remarkable, is that even whilst the lesser globes are still within the parent, they sometimes produce a third series, so that a parent Volvox often carries about with it two generations one within the other.

* Very inappropriately, for the word signifies "animal germs."

"This, you will perceive, beats our ivory puzzle-balls, which you have doubtless been accustomed to regard with wonder; and if the Volvox, which is just visible to the naked eye as a little green speck, has caused you so much admiration, what will you say when I tell you that the little green cells of which it is composed are quite as highly organised as the Volvox itself?

When examined with a high microscopic power, these gonidia are found to be pear-shaped and imbedded, as I said before, in the gelatinous membrane that forms the globe, through which the vibratile cilia alone protrude.

Near the apex or point of the pear-shaped drop is a little bright red spot, supposed by Ehrenberg to be an eye-spot (pl. vi. fig. 9*a*)."

"Ehrenberg! who is he? and if it has an eye, how can your Volvox be a plant?"

"At some future time I may tell you who Ehrenberg is; and as to the so-called eye-spot, it is common to many plants, and has nothing to do with vision; its nature is not clearly defined.

In the contents of the cell, composed, as already stated, of green granules, there is a curious little transparent cavity, in all probability filled with fluid; and this contracts and expands rhythmically at intervals of about forty seconds, the contraction taking place suddenly, and the dilatation slowly; and now I must add that this contractile cavity is found not only in some other known plants, but also in a great number of the lowest animals; so you see by how many different features these two forms of life are linked together. It is no wonder that, even now, men of the highest intelligence differ as to the true nature of a great number of types; some believing them to be plants, and others animals.

I fear, however, that you will be wearied with my lengthened account of this wonderful little living plant, and shall, therefore, draw the story of its life to a close.* If you examine it in autumn, you will find that the inner globes present quite a different appearance to what they do in summer. Instead of possessing a green colour, they are of a brownish orange, and the transparent envelope in which they are clothed is much thicker than it was in those that were developed during the summer. This is the winter garb of Volvox (pl. vi. fig. 10); in this state the germs rest until spring, when they are resuscitated; but how they come at that season to assume their emerald appearance, and what changes they then undergo, remains, along with many other features connected with the history of the plant, a

* During its transformations, Volvox presents a great variety of forms, some of which are delineated in plate vi., figs. 11, 12, 13; the last being the *amœba* or changeable form, in which the little cells lose their permanent shape, and resemble the lowest forms of animal life.

mysterious problem, still to be solved by persevering microscopical observers.

Although each of the little plants is, as I have already said, visible only to the practised eye without the aid of the lens, yet the water in which they are found is often tinged with green, in consequence of their vast numbers; so you see that whether we look up into the heavens and inspect the bright revolving worlds above, or down into the waters, and there consider the little animated globes, we still find innumerable evidences of His handiwork."

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# IRON AND STEEL.

BY ROBERT HUNT, F.R.S.

FROM the buried palace of the kings of Assyria, Mr. Layard sent to England some good examples of art-manufacture in metal. With these we have at present no concern, except, for an important piece of information which one specimen conveyed to us. This specimen was a casting in bronze of the fore leg and the foot of a young fawn, very delicately modelled. It evidently at one time formed a support to a table or lamp, or it may have been to some household god. This example of Assyrian metal-work was so slender, and yet so strong, that it was thought there must be some peculiarity in the composition of the bronze, to enable it to support, without bending, the weight which probably rested upon it. A fragment was analyzed, and found to consist of copper 88·67 grains, and of tin 11·33—about the usual composition of the ancient bronzes. In cutting off the fragment for analysis, a curious discovery was made: a rod of *iron* passed through the leg, as a core, around which the bronze had been cast.

This proves not only that iron was known, but that it was commonly employed where strength was required, when the line of Belus tyrannized over all the land, from the mountains of Judah to those of Caucasus. It is not intended to discuss the question, whether the sacred historians, or the Greek poets, have described the metals which we now call Iron and Steel; it is enough for us to know, that, at a very early period, there existed a knowledge of some of the best qualities of iron, and that it was an article of manufacture. The point to which we desire to call especial attention is, that man has certainly been using iron for nearly three thousand years,—that he is still ignorant of the causes producing many of its peculiarities,—and that our best chemists are at this moment disputing whether Carbon or Nitrogen is the element which converts iron into steel.

England is peculiarly the land of iron manufactures. In no part of the world has iron ever been produced in such enormous quantities, and in such a variety of qualities, as in the United Kingdom. Our blast-furnaces are pouring out annually a molten stream of nearly *four millions of tons* of this metal, and our Mills and Forges are—like the caves of the Cyclops—for ever boiling and glowing—as this is being converted by the might of man's industry into merchantable iron and steel.

The command of the Creator to man was that he "replenish the earth and *subdue it*." That he is fulfilling this, will, we think, be admitted by all who will reflect on the perils of the miner's subterranean toils, to procure a crude and uninteresting stone,—and will follow us as we endeavour concisely to describe the more important processes to which this is subjected, and the purposes to which its products are eventually applied.

Let not our readers suppose that a technical paper on the properties of iron is intended. We refer all who desire detailed information to the works of Percy, of Fairbairn, of Phillips, and others; our purpose being, to interest the least technical mind, by describing the curiosities of a manufacture which has given to England her commercial supremacy, and by the power of which she holds the key to all the markets of the world.

Iron has been made in England from the earliest times. In the same manner as the native of the Himalayan mountains now builds his rude furnace of clay, lights his wood fire, and charges it with iron-ore,—urging it by the blasts of his sheep-skin bellows, until he obtains his small lump of "wootz,"—so did the first iron-makers in Britain—probably before Cæsar came; and they have left us their "old cinders," and their "bloomaries," to inform us how perseveringly, even in the childhood of our race, our forefathers sought to avail themselves of the mineral treasures of the land.

In the Forest of Dean, on the hills of Cleveland, in the valley of Furness; wherever, indeed, man now pursues his search for the ores of iron, he finds the evidences of ancient workings. The history, however, of iron manufacture in this country is extremely obscure. That it was considered of great importance, is proved from the circumstance that the chief smith was an officer of considerable dignity amongst the Anglo-Saxons. In the courts of the Welsh sovereigns, the king's smith sat next the domestic chaplain, and he "was entitled to a draught of every kind of liquor that was brought into the hall;" and at the time of, and long after, the Conquest, every military chieftain maintained his smith, to whom many peculiar privileges were allowed. Tradition points to the Northmen as the most important iron-smelters; the heaps of scoriæ existing in many parts of England being still called "*Danes' Cinders*." When we begin to have any true history of these metallurgical operations, we find the seat of our iron manufacture in the eastern and south-eastern counties. The Green-Sand formations, which extend from the Humber, on our north-eastern shores, to the southern coast, near Dorchester, yielded abundance of iron-ore; and the counties of Suffolk, Essex, Kent, and Sussex, were thickly covered with timber trees, from which charcoal in large quantities was made. With these facilities for making iron,

numerous furnaces sprang up, and there appears to have been a steady increase in the manufacture of iron and steel in England.

In 1615, Dud Dudley informs us that there were 300 blast-furnaces in active operation, producing in that year 180,000 tons of iron, for which 144,000 tons of charcoal were required; to produce which, 17,310,000 cubic feet of timber were necessary. At the same time, according to the same authority, 500 Forges and mills for refining were at work. From this statement we learn that each furnace yielded somewhat less than twelve tons of iron a week. Dudley again informs us of his proceedings at Hascobridge, in the parish of Sedgley, after he began to smelt iron-ore with coal, "in which work he made *seven tuns of iron* per week, the greatest quantity of pit-cole iron that ever yet was made in Great Britain." The difference between the powers of production then and now, will be evident when we state that 400 tons of pig-iron have been, on many occasions, made in one week from the best modern blast-furnaces. Even at the beginning of the seventeenth century, the rapid exhaustion of the forest trees, by the demands of the blast-furnace, was a subject of serious consideration. The amiable Evelyn, in the sixteenth century, regrets that Nature had placed her iron-ores near flourishing forests; and, describing some of his loved trees, he exclaims; "What a pity such goodly creatures should be devoted to Vulcan!" At this time Essex appears to have been the centre of our iron industries, and Thaxted—now known only for its beautiful church—was the emporium of our steel manufacture, and possessed many especial privileges in consequence. There were, however, several extensive, and then important, works in the Forest of Dean, in some of which Oliver Cromwell appears to have been an active partner.

Wood was failing: then Simon Sturtevant and John Rovenzon made much noise about their experiments on smelting iron with pit-coal. They did not succeed. Dud Dudley followed them; he obtained some patent rights mainly on the plea that "if wood and timber should decay still and fail, the greatest strength of Great Britain, her ships, &c., and his Majesty's navies and men-of-war, for our defence and offence, would fail us." With much industry and irrepressible zeal, he pursued his experiments on "making of iron with pit-cole or sea-cole," and eventually succeeding in producing good metal. Dudley became the founder of the remarkable industry which distinguishes South Staffordshire. The forests were now allowed to grow, the demand for charcoal fell off, the iron manufacture of eastern England passed to the Midland counties, the steel trade left Thaxted and became the staple of Hallamshire, now better known by its chief town, Sheffield.

In Dud Dudley's time, 300 blast-furnaces produced 180,000

tons of iron in each year: in our time, 600 blast-furnaces—the number now at work—are pouring out annually nearly 4,000,000 tons of pig-iron. Beside those, three small furnaces exist in the neighbourhood of Ulverstone, and one in Scotland, in which charcoal is still used as the fuel: it rarely happens, however, that more than one of these is "in blast" at the same time.

The enormous development of the iron manufacture of Great Britain appears to have been due to the circumstance to which Dud Dudley was the first to direct attention,—that our best iron-ore, and good coal for smelting it, are, in many cases, associated. Dudley's quaint arguments to persuade the king to grant him a patent are amusing. Amongst other things, he says, as a reason why his prayer should be heard,—"Because in most of the coale mines in these parts, as well as upon the Lord Dudley's lands, are Coals, Ten, Eleven, and Twelve yards thick; the top or the uppermost cole or vein gotten upon the superfices of this Globe or Earth, in open works. Under this great thickness of coal is very many sorts of Iron, Stone, Mines, in the Earth, Clay, or Stone earth, like bats, in all four yards thick; also under these iron mines is several yards thick of coals," &c. &c. Dud Dudley, as he was the originator of the process of smelting iron with pit-coal, so he was the type upon which all iron-masters since his time have been built. To the untiring industry, and that indomitable force of purpose, which has ever led them through periods of deep distress,—and to that irrepressible will which knows no difficulty, must be referred the position which England holds amidst the metallurgists of the world.

In parenthesis,—we are constantly told that many of the continental states have proved themselves to be superior in metallurgical knowledge to ourselves. In answer to this, let us always remember that their superiority exists in the clever *books* they have written: our supremacy is secured by the *work* we have done. Nature has given us the raw material, and British heads and hands have moulded it into every possible form, whether for use or ornament. We have practically performed the trick of transmutation, and converted our iron into gold, while other people have been writing ingenious theories on the possibility of doing it.

This essay would be incomplete if it did not describe—although it can do so but briefly—the sources from which we have derived our enormous supplies of iron ore.

In South Staffordshire exist the beds of argillaceous, or clay-band ironstone, to which Dud Dudley drew attention, interstratified with the coal. We have the same conditions in Wales, in Yorkshire, in Derbyshire, and other of our coal-producing counties. In Scotland, Mr. Mushet drew attention to the "black-band ironstone," and thus founded that large industry

which marks the country near Glasgow. These were the sources from which we drew all our carbonaceous iron ores, from which the greatest proportion of British iron has been made.

Another carbonate of the protoxide of iron has, within a few years, attracted attention. Now and then a few ferruginous stones were found strewn over the beaches on the north-eastern coast of Yorkshire, but a long time elapsed before it was discovered that they had fallen from a higher level, and that a massive bed of this material could be traced by its outcrop for miles and miles along the escarpments of the Cleveland hills. From this district we now draw annually more than a million and half of tons of iron ore; and many are the fitful tongues of flame which indicate the existence of the iron-furnace over this once solitary region.

From the neighbourhoods of Whitehaven and Ulverstone are obtained the red Hematite ores, or anhydrous oxides of iron, so well known for their richness, and highly appreciated, for mixing with inferior ores, and improving the quality of iron. The deposits of this beautiful peroxide of iron occur in the Whitehaven district in a most massive form, usually in the Millstone Grit and the Mountain Limestone series, filling in vast caverns, which had been previously formed. In the Ulverstone district the iron ore is equally rich, but it is not of so coherent a character; and it may be inferred, from the order of occurrence, that the ore had been precipitated from water flowing through clefts in the rocks, or reposing in large lakes.

The brown hematite ore, or hydrated oxide of iron, of Dean Forest has been formed under somewhat similar conditions, and that which has lately been discovered at Llantrissant is of a like character. The older rocks of Somersetshire and Devon yield both the peroxide of iron and that peculiar form of carbonate which is commonly known as Spathic ore. On Exmoor, and over the Brendon hills, large works have been established, and in the south of Devonshire, near Newton Bushell, at Brixham, and near Kingsbridge, these ores are worked. Again, in Cornwall, the Restormel iron mine,—dignified with the title of Royal, because her Majesty the Queen once explored its subterranean recesses,—and numerous mines around St. Austell, produce the brown hematite. This and spathose ore are also largely mined on the northern coast of Cornwall, where an iron lode 100 feet wide is seen in the cliff, which has been traced for many miles inland. Even yet we have not told all our known resources. At Whitby, in Yorkshire, above the beds which clearly correspond with those of Cleveland, occurs a more recent bed in the Oolitic rocks. This may be traced towards the Humber; and on the southern side, in Lincoln-

shire, at a few inches below the surface, it spreads out in a bed of peroxide of iron, varying from six to twelve feet in thickness. At Scunthorpe this is largely worked, and also near Kirton-in-Lindsey. A formation similar in character, and probably the same in geological conditions, is seen at Peterborough and at Stamford. It then spreads over Northamptonshire and the adjoining counties, where it is worked extensively. At Westbury, and at Seend, in Wiltshire, immense deposits of iron ore again occur, and at both of those places blast-furnaces have been built, which make iron entirely from the ores of each locality.

Such is a very rapid sketch of the more important sources of our large supply; in addition to which we imported, in 1860, 23,112 tons of foreign ore. Iron and coal are the great supporters of British power. On these our manufacturing capability depends; and as this power of production places us now as the first of commercial nations, we must, as the power weakens, recede in the scale. The following table shows the present rate of exhaustion going on in our coal-fields and our iron deposits:—

TABLE OF IRON-PRODUCING POWER IN 1860.

| Name of County or Country. | Iron Ore Raised. | Pig-Iron Produced. | No. of Works. | Furnaces in Blast. | Coals Produced. |
|---|---|---|---|---|---|
| | TONS. | TONS. | | | TONS. |
| Northumberland.. | 12,500 | 69,093 | 8 | 7 | 18,244,708 |
| Durham ..... | | 340,921 | 19 | 37 | |
| Yorkshire ..... | 1,727,019 | 346,765 | 23 | 50 | 9,284,000 |
| Lancashire..... | 520,829 | 81,250 | 4 | 8 | 11,350,000 |
| Cumberland ..... | 468,781 | 87,950 | 5 | 8 | 1,171,052 |
| Derbyshire, &c. ... | 370,500 | 125,850 | 16 | 23 | 5,670,000 |
| Shropshire..... | 165,500 | 145,200 | 13 | 26 | 850,500 |
| Staffordshire ..... | 1,523,929 | 616,450 | 80 | 133½ | 7,648,300 |
| Northamptonshire | 95,664 | 7,595 | 2 | 3 | — |
| Gloucestershire ... | 90,466 | 26,458 | 4 | 4 | 4,350,900 |
| Wiltshire ..... | 76,201 | 21,875 | 2 | 4 | — |
| Somersetshire ... | 24,101 | 1,960 | 2 | 1 | 942,000 |
| North Wales..... | 85,097 | 49,360 | 8 | 8 | 1,750,000 |
| South Wales ..... | 630,705 | 969,025 | 49 | 147 | 6,254,813 |
| Scotland ..... | 2,150,000 | 937,000 | 33 | 131 | 10,900,500 |
| Cornwall ..... | 23,953 | — | — | — | — |
| Devonshire..... | 3,836 | — | — | — | 10,500 |
| Hampshire..... | 6,119 | — | — | — | — |
| Warwickshire ... | 19,500 | — | — | — | — |
| Oxfordshire ..... | 5,833 | — | — | — | — |
| Lincolnshire ..... | 16,892 | — | — | — | — |
| Isle of Man ..... | 1,671 | — | — | — | — |
| Ireland..... | 106 | — | — | — | 119,425 |

The question of the duration of our coal-fields has been asked, and, most unfortunately, it has been answered by loose guesses and random speculations, which are not worthy of any reliance. The means of determining the problem with accuracy exist; but they have not been made available. Quite independent, however, of this question of duration, we should open our eyes to the fact, that coals are becoming every year more costly; and they must continue to increase in price; this being in strict accordance with the old Staffordshire proverb, which says, "*He that liveth longest let him fetch fire further.*" As the workings extend, the cost of obtaining the coals must increase, and with this, either the profits of the manufacturer must diminish, or the price to the consumer advance.

In 1860 we smelted 8,024,205 tons of iron ore, the value of which was about £2,466,929; this produced 3,826,752 tons of pig-iron, valued at the mean average market price of the year at £12,703,950. Of this we exported, in the form of pig-iron, 342,567 tons, reserving 3,484,185 tons for manufacture. Upon this hundreds of puddling-furnaces were unceasingly employed, converting the crude-cast pig-iron into malleable iron; and mills, Cyclopean in every sense, were rolling this into bars, rails, and sheets.

Did our space permit us, we should have desired to examine with some care the conditions of the iron ores of this country. It does not; and we therefore, with satisfaction, refer to the "Memoirs of the Geological Survey," which embrace "The Iron Ores of Great Britain." In these will be found analyses of all the important iron-stones, made with the utmost accuracy, under the care of Dr. Percy,—the cost of this great work having been mainly met by a handsome contribution from Mr. Samuel Blackwell, of Dudley, to whom, it will be remembered, was due the valuable collection of iron ores which were in the Exhibition of 1851, and are now in the Museum of Practical Geology.

Leaving, therefore, the character of our iron ores to be sought for from the source indicated, it is necessary that the conditions of iron, as a manufactured article, should engage our attention.

Iron is the most common of metals; we have been manufacturing it for hundreds of years, and a large amount of mental labour has been bestowed on its examination. Still, it is doubtful whether iron in a state of absolute purity is known to us. If we take pure oxide of iron, and reduce it in a tube, at a red heat, by passing hydrogen over it,—the only method by which the pure metal can be got,—we obtain a spongy mass, which takes fire spontaneously upon exposure to the air. We know not if this is due to the porous character of the mass,—by which it acts mechanically on the oxygen of the air, as does spongy platinum, or if it is owing to the intense affinity of the

pure metal for oxygen. The purest commercial form of iron still contains about half per cent. of carbon, some nitrogen, with traces of silicon and other metals. Two analyses of cast iron, of each variety,—that is, "*cold-blast*" and "*hot-blast*," will convey a good idea of its composition.

| | COLD-BLAST. | | HOT-BLAST. | |
|---|---|---|---|---|
| | **1.** | **2.** | **1.** | **2.** |
| Silicon ..... | 1·050 | 1·400 | 2·500 | 3·140 |
| Graphite ..... | 3·370 | 3·184 | 3·520 | 3·100 |
| Sulphur ..... | 0·024 | 0·037 | 0·045 | 0·090 |
| Phosphorus ..... | 0·210 | 0·314 | 0·318 | 0·422 |
| | Metallic Iron, 93·15 per cent. | | Metallic Iron, 95·0 per cent. | |

It is necessary that we should convey to the reader, who may not be familiar with the technicalities of iron manufacture, some idea of the process by which the metallic iron is obtained, and give some explanation of the peculiarities of the hot and cold blast furnaces. With the mysteries of the *Catalan forge*, the *Fourneaux à pièce* of the French, and the *Stück-ofen*, or Salamander furnace, of the Germans, we shall not deal; attention will be confined to the ordinary English blast-furnace for smelting iron with coal or coke.

A person who has never visited an iron-making district cannot possibly realize the scene which it presents. Nothing in England is more impressive—we may say, more sublime—than the "Black Country" of South Staffordshire, as you are carried through it by the railway-train at night. A hundred blast-furnaces are belching forth their giant tongues of flame. The glaring white-hot eyes of *finery-furnaces* and *puddling-furnaces* look out into the darkness in fitful flashes. From scores of chimneys, red-hot vapour rushes wildly into the air, illuminating the ill-defined mills and forges to which they belong. All that is not black as night is intensely hot. Darkness and heat are two giants struggling for the mastery. With small aid from the imagination, the home of the Cyclopean smiths in the very roots of Vesuvius or Etna may be realized, or the Pandemonium of Milton fully pictured on the mind.

> "A dungeon horrible—on all sides round
> As one great furnace, flamed; yet from those flames
> No light, but rather darkness visible
> Served only to discover sights of woe—
> ———— a fiery deluge, fed
> With ever-burning sulphur unconsumed—
> With floods and whirlwinds of tempestuous fire."

Such is the external appearance of any of our large iron-works, the introduction to which is through those vast towers,

called blast-furnaces, which stand like the fiery wardens guarding the giant's castle, in those Teutonic legends that still live in Northern Europe. The *blast-furnace*, as usually constructed, is a circular brick tower, about sixty feet high, and at the *boshes*, or widest part, its width varies from fourteen to seventeen or eighteen feet. Its interior section exhibits two frustums of cones, meeting each other at their bases, at the widest part of the furnace; from which point it gradually contracts both upwards to the *mouth* and downwards to the level, where the *tuyères* (small apertures for admitting air) are situated; within this are placed the *fuel*, the *flux*, and the *mine*, or iron ore. The *blowing-in*, as it is called, or the first starting of an iron-furnace, is an operation requiring great experience.

A fire of wood is first lighted on the *hearth*, upon which coke is thrown, and when the whole is ignited, the furnace is filled by pouring in at the mouth regular charges of calcined iron ore, limestone, and coke. Blasts of air, urged by powerful steam-engines, are blown in through the *tuyères*, and the whole becomes an intensely incandescent mass. The size and power of those bellows will be best understood, by stating the fact, that an ordinary furnace making white iron requires nearly 7,500 cubic feet of air per minute, or it consumes 2,318 tons of our atmosphere in every week.

As the iron ore is acted on by the intense heat produced, it yields up its carbonic acid and its oxygen, and fluid metal flows into the lower part of the furnace, where it is collected and preserved, until a sufficient quantity is obtained for casting.

Moulds are made in sand, consisting of longitudinal channels, called *sows*, from which are formed lateral troughs, named *pigs*. The furnace is tapped by breaking away the clay which closes and secures the *tymp-plate*, on the removal of which, out flows a river of glowing whiteness, rushing onward through the sows, and rapidly filling the *pigs* with iron. The whole of the liquid contents having flowed out, the *tymp-plate* is again secured, and the operation of smelting goes forward as before. Furnaces are kept in blast for many years, yielding regularly from 200 to 400 tons of pig-iron per week; every ton of iron requiring the following proportion of materials, or thereabouts. (Half a dozen examples are given, as they vary at different works, and also with the quality of iron.)

| | 1. CWT. | 2. CWT. | 3. CWT. | 4. CWT. | 5. CWT. | 6. CWT. |
|---|---|---|---|---|---|---|
| Calcined Iron Ore ... | 48 | 28 | 46 | 35 | 27 | 37 |
| Hematite do..... | — | 10 | — | — | 10 | 7 |
| *Cinders* ..... | — | 10 | — | — | — | 11 |
| Coal ..... | 50 | 42 | — | 40 | — | 36 |
| Coke ..... | — | — | 34 | — | 34 | — |
| Limestone ..... | 17 | 14 | 16 | 5 | 15 | 5 |

The uninitiated reader must be informed that the *cinders* used are those which are produced in the processes of refining and puddling. They are often very beautifully crystallized, are rich in iron, but contain variable quantities of silicon, alumina, manganese, sulphur, phosphorus—in fact, all the impurities of the iron which are not dissipated by heat.

The difference between the "cold-blast" and "hot-blast" iron, just now referred to, is produced by a contrivance for heating the air before it is urged into the blast-furnace. The introduction of hot, in the place of cold air, in iron manufacture, was effected in 1827, by Mr. James Beaumont Neilson, of Glasgow. It will be evident, upon consideration, that a fire urged with air heated to 572° Fahrenheit's scale, must be more intense than a fire urged by air at the ordinary atmospheric temperature. The result, in practice, has been, that whereas formerly, by the cold blast, to produce one ton of pig-iron, 8 tons 1 cwt. of coal, converted into coke, were required; now a ton of iron can be made from the same ore with 2 tons 6 cwt. of coal.

It was contended by many persons, on the introduction of the system of smelting iron by the hot blast, that, although the process might enable the ironmaster to produce a larger quantity of metal economically, yet, in many of the qualities most desirable, the hot-blast iron was deficient. Long, and often angry, discussions ensued, yet cold-blast furnaces went gradually out of use, and the hot-blast apparatus was generally applied. The matter was, at length, submitted to experimental examination at the request of the British Association, Mr. William Fairbairn and Mr. Eaton Hodgkinson having charge of the inquiry. The points to be determined were—1. Direct tensile strength; 2. Compressive strength; 3. Transverse strength; 4. Power to resist impact; 5. Modulus of elasticity, or stiffness; and 6. Specific gravity. The report furnished, shows, conclusively that the sum of the advantages are in favour of hot-blast iron. The mean ratio of strength in cold-blast iron being represented by 1,000; hot-blast was 1,024·8; and the mean ratio of power, to sustain impact,* being in cold-blast as 1,000, it was 1,226·3 in hot-blast iron. One cause has been indicated, which, no doubt, leads, in some cases, to an inferiority. Heated air exerts a greater reductive power than cold air; consequently, in some furnaces blown with hot air, refractory iron ores, which could not otherwise have been employed, have been introduced into the furnace. They generally contain many impurities, and, consequently, inferior iron has been made. The advantages of hot over cold air, in iron-making, are many; and, without it, the anthracite coal of South Wales and of the United States could never have been employed; whereas this fuel is now becoming every year more valuable.

* The power to resist blows.

In the economy of iron-smelting, the collection of the gases escaping from the top of the blast-furnace, and their utilization, must not be forgotten. The chemical changes which are going on within the conical tower—where incandescent coal or coke, oxide of iron, and carbonate of lime are meeting with the oxygen and nitrogen of the air, at a very high temperature—are of a curious and complicated nature. They have been imperfectly studied. The experiments of Bunsen and Playfair at the Alfreton furnace, and those of Levi and Schmidt on charcoal-furnaces, gave some indications, which might, if followed out, have led to important results. The laborious nature of the investigation, and the difficulties attending it, appear to have checked all further inquiry. We know, consequently, but little of the *rationale* of the smelting process, which may be briefly stated to be as follows.

The gases formed during the operations going forward in the white hot mass—carbonic oxide, and much volatile combustible matter,—very complicated in its constitution, ascend at a high temperature. As the ore is supplied to the furnace, it meets those powerful reducing agents, and a portion of the oxide of iron is reduced to the metallic state. Combination also takes place between the iron and the silica and alumina present in the ore. The chemical affinities of the lime-flux then come into play. Silicates of lime and alumina are formed, and the slag thus produced contains but little iron; the metal being liberated, probably in the condition of pure or malleable iron. This descends further in the furnace, and, at the high temperature which there exists, it becomes liquid, combining with the carbon to form carburet of iron. Still descending through the material, there is no doubt but silicon and other alkaline metals combine with and materially influence the character of the iron. The cast iron obtained is very variable in its composition; it must, however, be regarded as a compound of iron and carbon, about four equivalents of the former to one of the latter, or, iron 94·9, carbon 5·1. When all this has been effected, immense volumes of gases intensely heated escape. These were formerly absolute *waste*. They are now collected, and carried, by means of pipes, to other furnaces, where, under favourable conditions, they can be made to produce a temperature varying from 3,210° Fahr. to 3,632° Fahr. It is stated on good authority that the saving of fuel with two furnaces making 240 tons of iron per week, by applying the waste gases to the blast-engine and hot-air stoves, has been £1,200 a year!

Such are the advances which have been made in the manipulatory details of iron manufacture, by which we are enabled to make cheaper iron than any other country in the world. With the chief varieties of cast iron, viz., *dark grey*, *bright grey*,

*mottled*, and *white*, we are well acquainted, and a good furnace-manager can determine, from known materials, the result which shall be obtained. With all the mysteries of *cinder-iron* are we also familiar; and it cannot but be regretted that there are manufacturers who study the art of sophistication so zealously as to produce a composition, still called iron, in which that metal occupies the minimum space.

We started with the assertion that although iron had been so long known to mankind, we were still imperfectly acquainted with its physical and its chemical properties. We repeat this, and cannot refrain from expressing a hope, seeing that the experiments required would be too expensive for any man to undertake, that some associated iron-masters would select a skilful and reliable experimentalist, place a furnace at his disposal, and meet all the expenses of this fine inquiry.

Crude pig-iron is a compound of iron and carbon, mixed with several substances. To produce wrought or malleable iron, a large portion of the carbon is to be removed, and the impurities dissipated. The process is essentially one of oxidation. It is not possible to describe in detail the structure of the "refinery," or oxidizing blast-hearth, nor to enter into the history of the process of "puddling," and discuss the several stages of the operation. It must suffice that we state, that the refining consists in placing about two tons of pig-iron upon a fire, lit in the centre of the refinery-hearth, covering it up with coke, and then urging the fire by a gradually-increasing blast until the iron is melted. It is kept in a perfectly liquid state under the influence of the blast for some time, the carbon combines with oxygen, and escapes as carbonic acid, while the adventitious metals are oxidized and volatilized. In the Welsh iron-works one ton of white iron takes from one and three quarters to two hours to refine, the consumption of coke being from six to eight cwt., and the loss of metal about three cwt. Instead of air, steam is often employed in the refinery process, and in general with the best possible result. In effect, the process is to blow the fire on the hearth, and act on the melted iron, with steam under a pressure of from 40 to 50 lb., and at a temperature of about 700° Fahr. We are informed that 396 cwt. of pig-iron produces by this process 393 cwt. of refined metal. The saving here is great, and half an hour appears a sufficient period for refining a ton of crude pig-iron. Refining by gas has been introduced, and by some highly approved. The *fine metal* produced by the refining process is subjected to the process of "puddling," introduced in 1783 by Mr. Henry Cort. The puddling furnace is so constructed that the intensely-heated vapour or flame plays or reverberates upon the melted metal, and being brought to a bright red heat, about four or five cwt. of fine metal

is introduced, together with some rich scoriæ or forge-cinders (scale oxide of iron). By the heat applied, the iron is melted, and the workman stirs it about with his poker so as to expose every part to the flame. The carbon is burnt off; the metal becomes less and less fusible, passes into a thick and tenacious state, so that it sticks together. The "puddler" now forms the iron into balls called "blooms." Each bloom is removed with a pair of tongs; it is compressed into a cylindrical form by a few blows from a heavy hammer, and then converted into a bar by passing it between grooved rollers. This is malleable iron, which is fibrous in its structure, and although the purest commercial form of the metal, it still contains about one half per cent. of carbon, with traces of silicon and other metals. The process of boiling iron, by which crude metal is converted into the malleable form without the intervention of the "refinery," is another mode of proceeding leading to the same end.

The Bessemer process has excited considerable attention, and it must be admitted to be a highly scientific one. Air is forced through a mass of fluid iron, the oxygen of which, acting on the red-hot metal, greatly increases the heat. The carbon, converted into carbonic oxide, burns off in a blue flame, the whole mass being in a state of violent ebullition, and the impurities are thrown up, as oxidized slag, in the form of froth. Mr. Bessemer says, "One of the most important facts connected with this new system of manufacturing, is, that all the iron so prepared will be of that quality known as *charcoal-iron*, because the whole of the processes being conducted without the use of mineral fuel, the iron will be free from those injurious properties which that description of fuel never fails to impart to iron that is brought under its influence." At that stage of the process immediately following the "boil," the whole of the crude iron has passed into the condition of *cast* steel of ordinary quality. By the continuation of the process, the steel so produced gradually loses its small remaining portion of carbon, and passes successively from *hard* to *soft steel*, from *soft steel* to *steely iron*, and eventually to very soft iron; *hence, at a certain period of the process, any quality of metal can be obtained.* Something more than the inventor states certainly takes place. In these days of Mechanics' Institutions, every person has seen the beautiful experiment of burning steel wire in oxygen gas. This experiment is entirely eclipsed by the brilliant display of sparks from the boiling iron undergoing the Bessemer process. Much iron is burnt off, and from the experiments made at Dowlais and at Briton-ferry, we learn that there was obtained "a mere mass of red-hot friable matter; which, from its crumbling and non-cohesion, was with difficulty formed into an ingot."

Experience appears to have modified the conditions. All varieties of iron are not advantageously treated by the Bessemer process; but some varieties, such as the Swedish irons and some of the very best British pigs, are now being converted into that valuable metal, existing in a state between iron and steel, employed for plating those ships of war which are to withstand the hammer-headed shots projected from an Armstrong gun. From a metal similar to this are made those remarkable pieces of Ordnance manufactured by Whitworth. There appears to be a stage in the process of converting iron when we have all the qualities of the best steel, combined with the valuable properties of malleable iron. This condition is arrived at by another process. Articles of various kinds, such as screws, pulleys, &c., requiring great toughness, are cast from the ordinary selected pig. In this state they are very hard, and consequently very brittle. These articles are placed in a furnace with a quantity of hematite iron ore, and the whole exposed for some time to a moderately high temperature. The peroxide of iron, under the action of heat, removes a certain portion of the carbon, and exceeding toughness results from the operation. Stirrups, bits, spurs, and much saddlers' ironmongery, are now made by this process. Although this operation has in many respects the character of annealing, yet it is something more. It is quite certain that a molecular change takes place by the long-continued action of heat alone; beyond this, however, the presence of the peroxide of iron determines by chemical action the constitution of the metal. Very fine castings, many of them copies of examples of high art, are made by this process. A very liquid metal is obtained to secure the requisite sharpness. This would be brittle when cold; but by the combined action of heat and hematite, the requisite toughness is secured.

Before leaving this portion of our subject, the Berlin iron-castings claim some attention. Dumas has stated that these remarkably delicate productions are due to the presence of phosphorus and arsenic in the iron from which they are cast. These substances certainly have a tendency to give great fluidity to the melted iron, and fluidity is essential to the production of such filigree-work as we see in the elaborate bracelets, neck-chains, brooches, and fans which many of the Berlin foundries produce.

The reputed origin of this manufacture is interesting. At the time when the final struggle commenced between Prussia and Napoleon, the patriotism of the Prussian ladies was particularly conspicuous. They sent their jewels and trinkets to the Royal Treasury to assist in furnishing funds for the expenses of the campaign. Rings, crosses, and other ornaments in cast-iron

were given in return to all who made this sacrifice. These gifts bore the inscription, "*Gold von Eisen;*" and these Spartan ornaments are to this day much treasured by the possessors their families. The demand arising from these circumstances led to that wonderful delicacy so much admired.

Notwithstanding the statement made by Dumas, we have been assured by a Prussian founder that the Berlin castings are largely made from English iron, and that the whole secret of the manufacture consists in securing the necessary fluidity of the melted metal by a very high temperature. A fine silicious sand is required to form the moulds, and this, Ehrenberg informs us, is entirely composed of the shells of microscopic animalculæ, which once swarmed in the ancient seas that united the Baltic with the Black Sea.

Where chains are produced in Berlin iron, the central rosette of each link is the only portion really cast, the loops forming the connection being of wire bent to form, and laid into the prints provided for them in the mould. This being arranged, the metal to form the rosette is run in, fills the impression of it, and surrounds the ends of the iron rings; thus forming the link. We have, however, had in our possession a chain made by a German workman, at the Hayle foundry in Cornwall, which was nearly five feet in length, consisted of 180 links, and weighed about an ounce and a half, the whole of which was cast. It is curious to contrast these delicate castings, weighing but a few grains, with such enormous castings, as the cylinder of the hydraulic press which was used to raise the Britannia tube into its place, and to push the Great Eastern to her home of waters;—the weight of which was twenty-two tons.

We must pass on to Steel. It has been shown that pig or cast-iron is a compound of iron and carbon. The malleable iron is produced by depriving the metal of much, but not all, of its carbon; and we have now to show that steel is another compound of these two elementary bodies. If we place together the chemical constituents of each of those states of iron, the peculiarities will be at once evident.

| | CARBON. | | IRON. |
|---|---|---|---|
| Pig Iron..... | 5·1 | ... | 94·9 |
| Malleable Iron ..... | 0·25 | ... | 99·75 |
| Shear Steel ..... | 1·5 | ... | 98·5 |
| Cast Steel ..... | 2·0 | ... | 98·0 |
| Indian Steel (*Wootz*) ..... | 7·18 | ... | 92·82 |

In India, and in some of the Continental States, especially in Westphalia, Styria, Siegen, and in Sweden, steel is prepared directly from the ores of iron, and is known as native steel. In these places, charcoal is employed as the fuel; but certain manipulatory details, into which we cannot at present enter,

must be closely attended to. In Germany, a puddled steel, which is much in request, is prepared by a process analogous to the puddling of iron; the only difference being, that as soon as a sufficient quantity of the carbon has been removed, the access of air is prevented, and the carbonized metal is retained, without change, in a molten state for working. This puddled steel is not so much used for cutting-instruments, as for the steel ornaments, and fancy articles which the Germans produce so largely, and for steel axles, winches, tires, &c.

The Indian *wootz* is prepared from a very rich magnetic oxide of iron, by a rude process, differing indeed in no respect from that which the natives of India employed when Alexander marched into Asia with his conquering army. In the first place, a cake of brittle grey iron is produced, with considerable waste in the slag. Cakes are carefully selected, annealed for several hours in small charcoal furnaces, finally carefully remelted, and cast into ingots. The finest ingots are taken and drawn out by a hammer of a few pounds' weight. Thus the finest Indian sword-blades are manufactured. Damascus steel, which is principally worked up into sword-blades, consists of a more highly carburetted steel than any European manufacture; and the peculiar characteristic Damascened patterns which appear on the steel, are due to a skilful cooling, by which a division is effected between two carburets of iron. The wonderful temper of the Indian and Damascus blades, which has been almost the despair of European cutlers, is due to the regulated temperature at which the blade is worked. If this be too high, the metal flies to pieces; if too low, it becomes hard and inflexible. The Indian steel has been cleverly imitated by combining nickel, manganese, and tungsten with the iron, and also by welding together plates of iron and steel. None of these imitations, however, possess all the peculiarities of the Damascus steel.

Steel differs from wrought iron in possessing the remarkable property of becoming intensely hard, if, after having been made red hot, it is plunged into cold water. If the metal has been brought up to a melting heat, and then suddenly cooled, such an arrangement of the particles takes place as to give the steel a hardness sufficient to scratch glass. By the process known as "tempering," almost any degree of softness can be obtained. In the entire range of metallurgy, there is no operation more deserving attentive study than this. The surface of the steel is polished, and it is exposed to heat. As the heat is increased, there is a curious and uniform change in the colour of the surface. The first visible tinge of yellow increases the toughness without diminishing the hardness; a deep yellow or orange indicates that the condition is that which is fitted for razors or

penknives; a yet deeper orange is required for table cutlery, and joiners' edge-tools; and a blue for watch-springs. These colours have been referred to oxidation; but it is by no means satisfactorily shown that they are not due to a molecular arrangement, quite independent of any chemical change.

Our process of preparing this useful metal is, to subject selected iron—usually Russian or Swedish—in contact with small pieces of wood-charcoal, in closed vessels, to a very high temperature, for some time, with a total exclusion of air. Different kinds of iron produce steels of different characters; therefore the persons who possess this knowledge are enabled to prepare steel fitted for any required purpose. The Bessemer process has been employed with considerable success in the manufacture of steel. One advantage is, that the decarbonization of the iron can be regulated with great accuracy. A given amount of air passed through the incandescent iron, produces a known result, and this is registered by a dial. This process has advanced but slowly in England; in Sweden, it has been extensively employed. Large steel circular-saw-plates have been made by Mr. Göranson, the ingot being cast direct from the fluid metal, within fifteen minutes of its leaving the furnace. At Bordeaux furnaces are at work especially on this principle; and at Liège, from the native coke-iron, beautiful steel is made by the application of the discovery of Mr. Bessemer. At Sheffield, however, not only at the inventor's works, but in some other large establishments, the process of blowing air through the molten iron to produce malleable iron and steel is now in use.

All that has been attempted in this sketch is to give a sufficiently intelligible description of the processes by which our iron ores are converted into those metals which are so important to our manufacture and commerce, our main purpose being to indicate the large field of inquiry which is yet open to any zealous investigator. The iron ores of the United Kingdom have been analyzed with the most scrupulous care. These analyses, published in the "Memoirs of the Geological Survey," may be regarded as the first step in the larger inquiry. Within the last year, considerable attention has been directed to the phenomena of steel manufacture, from the publication of the investigations of M. Fremy. In his researches, this eminent chemist has arrived at the conclusion, pointed to previously by M. Despretz, that nitrogen exercises an important influence over the phenomena of steeling, and that carbon plays a less necessary part. M. H. Caron, M. H. St. Claire Deville, and others, differ from M. Fremy, and still refer the formation of steel to the chemical combination of the iron with carbon.

Iron ore is raised from the earth at a cost of three or four shillings the ton. After an outlay of thousands in the building

of furnaces and the construction of the necessary works,—and after all the cost of fuel, flux, and labour, iron is made at less than £3 the ton. By every movement this price is, of course, considerably increased, and by certain processes of manufacture it is augmented in a remarkable manner. The best iron, for example, costs rather more than 3*d.* per pound, and out of this, 50,000 hair pendulum-springs for watches can be made, at 2*d.* each; thus raising the value of the pound-weight of iron to upwards of £400! The skilled labour of the ornamental iron-caster so increases the value of the crude grey iron, in the manufacture of articles of use and ornament, that it reaches, in many cases, to ten thousand times the original cost of the material. These curiosities of manufacture,—upon which an interesting essay might be written,—represent the value of man's creative power in rendering the productions of nature the means for improving the condition of the human race. They are the outward and visible signs of the moulding power of the mind of man; and although we are forbidden to worship the work of a mortal, yet a due appreciation of his handiwork leads to a more perfect understanding of that Immortal Power, from whom creation springs. The Britannia Tube, the Tamar Bridge, the Crumlin Viaduct, the Suspension-bridge of the Menai Straits, or the High-Level Bridge across the Tyne, are the works of Titanic minds, and as such, they possess the power of elevating every human being who looks on those examples of engineering skill. The *Great Eastern*, the *Warrior*, and the *Black Prince*, are evidences of power, which morally give strength to the men of the country to which they belong. The thousands of miles of iron bars which are laid over our Island do more than enable us to pass with celerity from place to place. They are breaking down the barriers of prejudice, they are destroying the walls which separated the town and the country; and both are gainers thereby.

Man begins to ascend towards Heaven, the moment he seriously exerts his mental gifts. The breath of life which was given to him by his Creator, was an influence of a far more exalted character than any of the Physical Forces, which are so terrible in action, but which are subjugated to human will. By the might of mind, man takes the dust of the earth, and he seizes the spirits of the air; he brings one to act in force upon the other, and the result is a *creation* for good! What Teutonic god, what Oriental Enchanter, ever performed so vast a work as that of rearing across a strait of the sea, a tube to endure for ages the rushing to and fro of a Behemoth of man's creation, whose "bones are as strong pieces of brass; his bones are like bars of iron,"—which draws after him in safety hosts of men? What Celtic Sprite ever fabricated from the crude masses of "the

earth's foundations," so fine a film as that which man has spun in the hair-springs that mark the tread of time? or wove from such coarse materials so delicate a tissue, as those iron ornaments which hang around the neck of beauty? "Iron is taken out of the earth, and brass is molten out of the stone." The promethean power which made man a metallurgist, advanced him as an intellectual creature, and every step we take in subduing nature, according to God's command, elevates the whole human race another degree above the Earthiness of this existence.

# ARTIFICIAL LIGHT.

BY D. T. ANSTED, M.A., F.R.S.

UP to the close of the last century the best contrivances in use for obtaining artificial light were limited to oil lamps of very imperfect and uneconomical construction, and candles of wax and tallow. Blazing torches of pine, ends of rope soaked with tar, and occasional bonfires of tar-barrels, might serve for special occasions, but could hardly be looked upon as available for ordinary purposes, and other better contrivances were unknown. In warm countries, where tolerably pure vegetable oils are easily and cheaply obtained, where the winter nights are not very long, and where, therefore, little artificial light is needed, a piece of twisted cotton or yarn partly resting in a saucer of oil serves all purposes. Lamps of the most elegant form, but of this very simple construction, were in all former times, and are still, used by all classes in Greece and Italy. Such lamps date back to the remotest antiquity, and a sea-shell has no doubt served as their original model. The jar of oil on a shelf always at hand serves indifferently for feeding the lamp and for cooking, and indeed many travellers have recorded, though by no means with satisfaction, that they have seen the very lamp itself, burning in the chimney, taken down from its place in order that a part of its rich contents might be poured out to assist in some savoury fry going on below.

In cooler climates, where the winter nights are much longer and where oil readily congeals, lamps were long ago replaced by candles. At first rushes, and afterwards cotton wicks, were dipped in hard animal fat or tallow in a molten state, and when cool were ready for use. A better kind of candle was made after a time, by pouring purified tallow into *moulds* in which twisted wicks were previously fixed; and hence the division of tallow candles into moulds and dips. Both required constant snuffing, and if long neglected were dangerous, owing to the unburnt carbon which collected at the top of the wick, and at last fell off in a state of red-heat.

Candles manufactured from beeswax, purified and bleached by long exposure to the sun and by some chemical processes, served as an admirable but very costly substitute for tallow; but no large quantity could ever have been obtained, and they could never enter into general use.

The sixty years that have passed since the beginning of this century have witnessed marvellous improvements in almost every article of domestic use, and so much has been added to the stock of common comforts, rendering many of the luxuries of former times quite indispensable, that the habits and tastes of all classes have become affected to an extent little thought of. In this matter of illumination a return to the former condition would involve so complete a subversion of our established customs as to be almost impossible; and this will be evident when we briefly describe the existing sources of artificial light and the present condition of manufacture in respect to them.

Candles are still used to an enormous extent: fifty thousand tons weight of tallow have been entered for home consumption in England each year during the last quarter of a century; but candles, originally made of tallow alone, although still manufactured of unpurified tallow, are to a great extent becoming replaced by those composed of a substance derived from various animal and vegetable oils. But while the consumption of tallow has remained nearly stationary, the population itself, and the quantity of artificial light of all kinds consumed by each family, have been increasing with great rapidity. Wax, like tallow, has continued to be imported, and is still used as before; and another curious substance—spermaceti—long since made into candles, has never been a common material. Unimproved lamps for burning common oils are also still in very extensive use; but, in addition to all these, many new sources of artificial light have been discovered; one of which, more than all others, has helped to turn night into day. We allude, of course, to the common coal gas, which is not only obtained at once by simple distillation from coal, but the manufacture of which has led to so many and such extraordinary results of other kinds, that it might well be regarded as one of the greatest and most useful discoveries of modern times.

The contrivances now commonly adopted for obtaining artificial light may be grouped under the following heads:—*First*, There are tallow candles, which are still largely employed. *Secondly*, Stearine, or composite, and, more recently, paraffine candles, which will ultimately, no doubt, replace tallow in domestic use. *Thirdly*, Wax and spermaceti candles, scarcely altered from their old construction, and which continue to be used for certain purposes, although the consumption is not increasing. *Fourthly*, Animal and vegetable oils used in lamps, either of the old kind or of improved construction. *Fifthly*, Certain mineral oils, such as naphtha, paraffine, and other similar substances, used also in lamps, and replacing oil to some extent. *Sixthly*, Coal gas, obtained by the destructive distillation of all

the varieties of coal; and oil gas, obtained by the distillation of oils. There are also two contrivances, one involving combustion in an oxygen atmosphere, and the other making use of the electric spark, which are both remarkable for the intensity of the light produced, but which are at present too costly and unmanageable to enter into general use.

Tallow candles have so unpleasant an odour, they are so apt to gutter or melt more rapidly than the wick can consume the tallow, they so generally smoke and choke the wick and require its constant removal by snuffers, and are so little economical in the most important sense of the term, that they will probably ultimately disappear from use. They are, however, sold at so low a price, and possess so many apparent conveniences, that among the lower classes they must long retain their hold.

The first improvement in the material used for candles dates as far back as 1799, when a person named William Bolts took out a patent by which he proposed to squeeze the tallow after melting, and while in the act of cooling from a melted state. The result of this squeezing would be to separate the tallow in some measure into its component parts; for, although it was not then known, chemists have since discovered that most animal and vegetable fats and oils are composed of at least two distinct solid bodies, one liquid oily substance, and one syrupy substance. Of all these, one only of the solid bodies is that which is really valuable for illuminating purposes. It is called *stearine*, and is the really valuable material in the candle. The syrupy substance above alluded to is now familiarly known and extensively used under the name *glycerine*, and, as the reader may easily satisfy himself, it gives hardly any light when burnt with a wick. The effect of squeezing melted tallow is to remove a large part of this peculiar substance. The same process was afterwards effected much more completely by chemical action, and is now managed by blowing steam at a high temperature through the melted fat or natural oil.

A series of brilliant experiments by two eminent French chemists, Chevreuil and Gay-Lussac, had so long ago as in 1825 cleared up the whole subject of the composition of fatty matters, their relative value for illumination, and the various methods by which their decomposition could be effected on a large scale; but it is only within a very few years that it has been found possible to practise these methods economically, and separate the *stearine*, which is the material best adapted for making candles, from the other solid contents of tallow and from a peculiar thick oil, which is very valuable for lubricating machinery, and may also be used for burning.

Some of the vegetable oils, especially those from various species of the palm-tree, are now extensively used in the manu-

facture of composite candles. For this purpose the fatty acids of one kind of palm require to be mixed with stearine obtained from another kind of palm oil.

The annoyance of having to snuff candles has been removed by plaiting and twisting the wicks after dipping the cotton in a solution of borax. The way in which this contrivance acts is simple enough. It depends on the fact that flame is a mere shell. Owing to there being no supply of oxygen gas within, a charring of the wick there takes place, as a natural consequence of exposure to the heat, but the carbon remains. When, however, the cotton has been previously twisted, the tension of the threads obliges the wick to curl outwards towards the shell of flame, where it becomes completely burned, while the earthy impurities of the cotton form a glass with the borax, and are thus got rid of without mixing with the fatty acids, which are apt to splutter if not protected in this manner.*

Candles made of the stearine of any common fat, whether animal or vegetable, can now be prepared so as to imitate and almost rival wax and spermaceti. The latter substance may ultimately be superseded altogether by chemical contrivances; but it is not likely that wax will ever be excluded from our drawing-rooms. The bleaching of wax and its preparation for use in candles have scarcely been altered or simplified, except by some trifling change introduced in the structure of the wick. The material which will ultimately take the place of wax is paraffine, already largely used, but not yet cheap enough to command the market.

Oil lamps have improved marvellously of late years. The ingenious contrivance bearing the name of its French inventor, M. Carcel, was a great step in the right direction. In this lamp the oil is raised by clock-work, so as continually to overflow at the bottom of the burning wick, which is thus never charred. The wick is circular, and a powerful draught of air is made to pass both within and without it by the use of a high glass chimney. Almost any kind of oil burns in it with great splendour, and for a long time without altering the wick. In this, and a number of contrivances known by different names, the principle involved is that of producing as nearly perfect combustion as possible of the oil by carrying a column of air rapidly in the interior of a thin circular sheet of flame. In carrying out the principle thus enunciated, a great and important stride was made towards a good cheap light, and most of the modern alterations have been mere adaptations, applied with more or less ingenuity and taste.

* See "Faraday's Chemical History of a Candle," mentioned in our List of Books.

The *moderator* is another form of lamp now in very common use. It involves two or three important principles, one consisting of a powerful spring, whose force is equal to from fifteen to twenty pounds, which presses on a disk and forces the oil up a tube, whence it flows over the burning wick, which is thus always saturated, as in the Carcel lamp. To prevent the oil, however, from flowing over too rapidly, there is placed in the tube an ingenious regulator, or *moderator*, of a tapering shape, which is so contrived as to check and diminish the flow of oil in proportion as the pressure is increased, always allowing sufficient oil to pass to feed the lamp when burning. The oil, being thus supplied with perfect regularity, just saturates a hollow circular wick, through the middle of which a current of air is constantly drawn by means of a glass chimney. A number of small contrivances introduced by Argand, the inventor of the circular burner, have brought it to a state of extreme perfection.

Common vegetable oils can be burned with advantage in lamps where the current of air is strong and where care is taken that the top of the wick is kept smooth; but all these oils are costly, and the quantity of smoke that arises from the unconsumed fuel is extremely disagreeable. Animal oils are not generally used, owing to the smell they emit when burning.

Mineral oils are now entering into large consumption, and of these the recently-introduced *paraffine oil* is one of the most remarkable. It will be necessary to consider a little the nature and preparation of this curious substance, if we would fully understand the very great change that has taken place of late years with regard to the methods of obtaining artificial light.

Paraffine, though only recently manufactured in sufficient quantity to be used practically, has been long since known as one of the products derived from a peculiar destructive distillation of vegetable matter, whether in the state of wood, peat, or coal. Various bituminous shales and other mineral deposits that abound in some parts of the world, also yield the same substance. It is obtained by carrying on the distillation in a retort kept at a low red-heat, the products being received and condensed at a temperature of about 55° Fahr. in a very carefully-contrived apparatus. A light oil is the principal result of this operation, and this oil, after being purified and re-distilled, is found to be a fluid compound, containing a certain proportion of paraffine oil, which greatly resembles clear transparent naphtha, a somewhat heavier oil, also used for burning, a lubricating oil, and solid paraffine. The light oils yield an intense white light, admirably adapted for general use.

In order to obtain a clear smokeless flame from paraffine oil, it is necessary to take some precautions. Owing to the capillary action of the cotton used as a wick, the fluid oil may be

kept at some distance from the flame, so that only the vapour in a heated state is ignited. What actually burns is thus a gas obtained from the paraffine oil by the application of moderate heat.

Many other naphthas (camphine among the number) have from time to time been introduced and tried in lamps; but it is only lately that any satisfactory result has been obtained. A disagreeable odour, not belonging to paraffine itself, and probably not essential to the oil, still characterizes the naphthas commonly prepared and sold; but this can be removed by certain processes of purification, and it may be expected that the consumption of paraffine oil will greatly increase. The paraffine oils have this great advantage over turpentine, and other light oils obtained in a similiar way, that they do not burn when exposed directly to flame, and they do not soil linen or adhere to the fingers.

Pure paraffine is itself a soft light solid, without taste or odour, melting at a temperature little above that of the blood (112° Fahr.), and burning with a clear white flame, without smoke or ash. It has already been made into very beautiful candles; but the manufacture at present has not attained great importance, although as much as 300 tons were employed in this way two years ago. The cost of obtaining pure paraffine is the present cause of this delay in the progress of the manufacture.

The minerals which yield paraffine oil on exposure to a low heat in a retort will yield to destructive distillation at a higher temperature a very large quantity of gas (chiefly carburetted hydrogen), which takes fire readily on exposure to flame; but those best adapted for the one purpose are least fitted for the other. Bituminous shales are best for paraffine oil, and coal for the manufacture of gas. The gas thus obtained, when freed from certain impurities, burns with an intense and nearly pure light, and is the common gas supplied for burning.

So long ago as in the year 1659, and again about eighty years afterwards, gas of this kind, issuing naturally from the ground in the neighbourhood of coal-mines, had been the subject of experiments of a scientific nature, which were communicated to the Royal Society, but no practical result was obtained till in 1792 Mr. Murdoch lighted his own house with a similar gas, and was shortly afterwards successful in lighting in the same way the factory of Messrs. Boulton and Watt at Soho. It was not till 1813 that any important step in lighting towns on a large scale was made, but from that period to the present day the consumption of gas for purposes of illumination has been increasing with such enormous strides that scarcely a town in the civilized world is now unsupplied with this admirable and useful means of turning night into day.

Coal is by no means the only, though it is certainly the principal, material from which gas is obtained. Bituminous shales, oil, resin, peat, and wood, are all capable of yielding a certain supply; and some of these substances, badly adapted for fuel, are extremely valuable for illuminating purposes, owing to the large quantity of light carburetted hydrogen gas that may be obtained from them. The presence of this gas in the actual pores of coal, whence it is given off in large quantities, is often intimated underground by a peculiar singing noise, and in some mines a naked light applied to freshly-cut coal will actually produce a flame from numerous small jets. This is probably owing to the great pressure brought to bear upon the remainder, when part of the coal is removed. A very much larger quantity of the same gas is obtained afterwards, by exposing the coal to intense heat in a retort, arranged so that the products of distillation shall be received in convenient vessels for the purification of the gas, and afterwards transmitting it by pipes to the place where it is required for burning.

Although, however, the process of obtaining gas that can be rendered useful for illumination is so simple, that every schoolboy has made the experiment in the bowl of a tobacco-pipe, the mechanical difficulties of applying it on a large scale were at first exceedingly great, and have only lately been overcome in a satisfactory way. All the gaseous substances that are obtained from the combustion of the coal are by no means fit for burning, as they include, besides the gas we use in our streets and houses, several other gases, more or less noxious and useless, and many vapours which require to be separated. Besides these, there are fluid, semi-fluid, and solid products either carried over or left behind. Even the illuminating gases themselves are many in number, and vary in their properties, some having a disagreeable odour, some being unwholesome and therefore objectionable for general use, and others exceedingly valuable as giving pure white light without adding to the heat of the mixture during combustion. The essential ingredients of illuminating gas are carbon and hydrogen; but all true coal contains, besides these, both oxygen and nitrogen gas and sulphur. These elements, either alone or in various new combinations, are obtained after rapid distillation at high temperature, so that watery vapour, ammonia, sulphuretted hydrogen, carbonate of ammonia, and a variety of compounds, of which paraffine and benzole are the best known, come off with the illuminating gas, and may be collected. They are present in quantities that vary according to the nature of the coal, the temperature employed in distilling, and the length of time occupied in the manufacture.

Not only, therefore, is there left behind in the retort a

certain quantity of coke, consisting of the carbon that has not combined with oxygen and hydrogen, mixed with the earthy impurities of the coal; but by various processes several liquid and solid substances, of more or less utility, become condensed on the other side, before the gases are entirely set free. The gases intended for burning require to be purified, so as to get rid more especially of the sulphur compounds and carbonic acid, an operation in which slaked lime is especially useful, as it absorbs large quantities of the most objectionable substances.

The gas being set free in a tolerably pure state, yields, within certain definite limits, a quantity of light greater in proportion to the carbon it contains. For this purpose, the poor and rich gases require to be mixed, the pure light carburetted hydrogen giving very little light at the ordinary temperature at which combustion is effected, and gases with too much carbon giving off smoke while burning. The mixture being made, the maximum light is obtained by a nice arrangement of the quantity of gas allowed to escape, and the draught of air admitted or forced to pass through the flame.

It is unnecessary to describe the ordinary contrivances used as gas-burners, although some of them are much more ingenious than others, and better adapted to give light. On a large scale, however, and in public buildings, the method of lighting that is adopted has such enormous influence on the health and comfort of those exposed to the atmosphere of the place, that it becomes a matter of the most serious consideration.

There cannot be a doubt that a large proportion of the headaches, sleepiness, and general discomfort felt in public buildings lighted with gas, where no special means are adopted for removing the products of combustion, are due to the accumulation of carbonic acid and other poisonous gases given off during combustion. While gas is burning, it removes from the atmosphere a large quantity of oxygen; and as this is also the result of breathing, the effect is soon felt where a large number of human beings are together. There is but one way of removing this great evil, but fortunately that method is fully adequate. It consists in the use of a ventilating burner, either resembling in its principles of action the burner originally contrived by Faraday, or of a still more simple arrangement, the whole of the jets being connected with an air-chamber and chimney, so placed that the draught carries off at once into the open air every particle of matter produced during combustion. Faraday's burner is an ordinary argand burner, of large size, with a chimney, surrounded by a wider and taller chimney, closed at the top, and opening at the bottom into another tube, that carries away the products of combustion. The star method of illumination involves the use of numerous groups of small jets

arranged concentrically, each group being arranged in the form of a star, and the whole forming a brilliant and steady volume of light. This latter is, beyond all comparison, the most pleasant and the brightest light that has yet been obtained artificially. It requires, however, a chamber and large chimney communicating directly with the outer air, and must be placed at the ceiling or roof of the room to be lighted. It is comparatively expensive, consuming a large quantity of gas compared with the available light yielded, and is thus little adapted for general use where economy is considered.

The quantity of good illuminating gas procured from a ton of coal varies greatly according to the nature of the coal and the method of manufacture. By the old process, the yield of gas rarely exceeded 10,000 cubic feet per ton of coal, except from some Cannel coals, especially rich in hydrogen; whereas, by what is called White's process, as much as 30,000 cubic feet have been obtained from ordinary kinds, and 50,000 from Boghead coal. The illuminating power of the gas made has also been increased by modern improvements, the increase amounting to from twelve to upwards of a hundred per cent. on the old method, according to the nature of the coal.

To give an idea of the value of the improvement in artificial light by the introduction of gas, we must enter into some small calculations. Taking sperm candles as the unit (each candle burning ten hours, at the rate of 120 grains per hour, and the value being about 4*d.*), the quantity of ordinary coal required to produce light equal to 1,000 such candles (value £16. 13*s.* 4*d.*), according to the old method of making gas, varied from four to seven hundredweight; while, if Cannel coal were used, about half that weight would be needed. At present, however, the consumption of coal for this quantity of gas would not exceed from 350 to 400 pounds of ordinary kinds, and of Cannel, from 105 to 160. With this quantity of coal (value about three shillings in London) from two to three thousand cubic feet of gas are manufactured, so that, under any circumstances, the cost of gas-light, compared with that of sperm candles, is not more than one-fiftieth part. In point of fact, however, with the methods of manufacture now adopted, and the increased illuminating power of the gas, it is estimated that the actual cost of 1,000 feet of gas of the best quality is little more than one shilling; so that artificial light really costs not more than one-hundredth part the price that it did fifty years ago.

In countries where coal is scarce and dear, wood, peat, and brown-coal all yield, on distillation at very high temperatures, certain illuminating gases, which can be purified for burning, and thus rendered available for general use. It is only very lately that a method of doing this has been adopted with

success; but it is said that wood and peat gas are already used with great advantage in many German and Swiss towns.

In addition to the contrivances adopted for obtaining artificial light already alluded to, and in common use throughout the civilized world, there are two others occasionally employed, although not yet produced on such a scale and at such a cost as to be economically important. One of these is merely a modification of ordinary gas-light, involving the use of pure oxygen gas, instead of atmospheric air, as the agent of combustion, and introducing a solid incandescent body, such as lime, to increase the intensity of the illuminating power. The other is the electric light, obtained by bringing into close proximity, without actual contact, two pencils of charcoal, and passing between them a powerful voltaic current. Great difficulty has been experienced in rendering light thus obtained sufficiently steady for any practical purposes, and these difficulties are not yet fully overcome, although a partial success has been obtained in Paris, by methods more simple and less costly than those before used.

And now, in bringing to a close this account of Modern Illumination, let us consider for a moment how far and in what way we are benefited by artificial light, rendered cheap and abundant by so many ingenious contrivances.

Half a century ago, all the great capitals of Europe, although then not half their present size, were dangerous residences to their honest inhabitants, and unmanageable in regard to police supervision, owing to the difficulty of obtaining sufficient artificial light during the long dark nights of winter. The growth of population that has since taken place, and the development of the resources of our own and other countries, would probably have been impossible, without the discovery and rapid introduction of some means of economically and effectually lighting the streets and alleys, which had long served as the haunts of thieves and dangerous characters of all kinds. It is not too much to say that, in this matter alone, the introduction of artificial light has been the main agent employed in effecting a social improvement, compared with which all others are secondary. The millions of cubic feet of gas now burnt nightly in our streets are, beyond comparison, the best, the most permanent, and the least expensive source of security that could have been introduced, and have served, more than anything else, to check those deeds of wrong and violence that darkness cannot fail to shelter, and invariably fosters.

Nor are we less indebted to gas for lighting our public buildings of all kinds. Here, again, the necessity for increased light has enforced a consumption of material which, as far as we can see, no natural supply of oil and tallow could ever have

satisfied. Of all these matters the supply, however large, is limited and costly, the cost increasing rapidly as the consumption becomes greater. The gradual but steady improvement in the quality and purity, and the great reduction in the cost, of gas has been met by a corresponding increase in the quantity used.

When so much better and cheaper a light than candles or oil lamps was first introduced and found so useful, it became almost inevitable that the old sources of artificial light should also be improved. Thus candles, as we have said, are now of greatly improved quality; they are made from various materials, formerly thought altogether inapplicable; the best of the present day are hardly more expensive than the worst of half a century ago; while in all important respects, the very materials that rendered the tallow candles of former times a nuisance to everybody, being now separated and applied to their proper uses, are found to possess a value positively greater than that of the combustible material itself, which they at one time interfered with and injured.

The scientific principles of consuming fuel so as to obtain light being also now better understood, there is far less waste than before in our lamps, and some of them are models of mechanical art, obtaining the most perfect result at the smallest expenditure of material. In all these matters the mechanical improvements and the application of chemical principles have gone hand in hand.

It is altogether impossible to exaggerate the value and importance of light; and it is certain that everything done to facilitate the means of obtaining and distributing artificial light cannot fail to be of general benefit to mankind. And if, looking at the glorious orb of day, and remembering all its life-giving properties, we exclaim with the poet—

"Hail! holy light—offspring of Heaven first born,"

we may, with equal propriety, regard in artificial light, however obtained, a younger, but hardly less useful and important creation, always at hand, requiring a certain development of human intelligence to render it available, but rewarding us by communicating a means of moral and intellectual light, as well as that physical illumination that is so useful and so indispensable.

# THE BREATH OF LIFE.

BY W. CROOKES, F.C.S.

NOT only figuratively, but in actual reality, can the life of man be compared to a fire, or lighted candle. Respiration may be regarded as the same process as combustion, only performed in a slower manner. Fuel is placed in a furnace, and the combustion which we see take place with the evolution of heat and light is owing to the combination of the oxygen—that wonderful constituent of the atmosphere—with the carbon and hydrogen of the fuel. In a similar way we place food (which is fuel) in our bodies, and then by the act of respiration we draw into the lungs oxygen, and this, uniting with the carbon and hydrogen of the food, also produces a disengagement of heat.

Another point worthy of attention is, that the combustible matter of the food—the carbon and hydrogen—when burned in the body by means of air drawn in by the lungs, produces exactly the same amount of heat as it would have done had the same quantity been consumed in an ordinary furnace by means of the free atmospheric oxygen; the only difference being, that in the latter case the combustion takes place rapidly, evolving an intense heat for a short time, whilst in our bodies the fuel is burned more slowly, thus evolving less heat for a longer time, the total amount of heat liberated by the combustion of a given weight of carbon, whether it be burned in the form of coal or beef, being always the same.

This, therefore, is the cause of the high temperature of the human body. We each carry about within us a portable furnace of the most perfect construction. Fuel is thrown on at intervals during the day, the need of a fresh supply being made known by the feeling of hunger (as it is in some steam-engines by the ringing of a bell); whilst a draught of air is drawn in at each inspiration, by which means the process of combustion proceeds uninterruptedly.

The analogy is strictly correct, even if pursued further. In a furnace we can augment the energy of combustion by increasing the draught of air; and so in our bodies, if we increase the normal number of respirations per minute, a considerable rise of temperature is the result, the excess of heat being radiated into the surrounding atmosphere, and carried off

in the form of perspiration. This explains why persons in Arctic regions consume such enormous quantities of food in comparison with those in more temperate latitudes. In order to keep up the natural heat of the body (which is invariably the same—99° 5′ Fahr.) in the midst of the intense cold of the surrounding media, it is necessary for considerable quantities of fuel to be rapidly burned in the body, so as to restore the amount of heat lost by radiation; and not only is the total weight of food which is required in the Arctic regions vastly greater than that consumed in warm climates, but the former contains a greater per-centage of combustible matter; the fruits which constitute so large a proportion of the food of the inhabitant of the South containing not more than about twelve per cent. of carbon, whilst the blubber or fat which forms the staple diet of the Esquimaux or Lap, contains nearly eighty per cent. of that combustible. Plenty of food, therefore, takes the place of clothing, in the same manner as warm raiment is a partial substitute for food. The warmer we are clad the less fuel it is necessary to burn in order to keep up the supply of animal heat lost by radiation; whereas, if we were to walk about naked or were exposed to an Arctic temperature, we should be enabled to consume twenty or thirty pounds of whale's fat together with several quarts of train oil and brandy without difficulty, finishing off with a few tallow candles by way of dessert, the combustible matters here indicated being not more than sufficient to supply the enormous radiation of heat consequent upon a difference of perhaps 120 degrees between the temperature of the body and that of the external air.

The analogy between the life of man and the flame of a candle or stove, is thus seen to be something more than a mere fanciful theory. Warmth and vitality are produced equally in each case by the combination of combustible matter with the oxygen present in the atmosphere; and in either case, if the supply of air be insufficient or vitiated, a similar result will follow; for the pale, sickly, flickering flame of a candle burning in an atmosphere deficient in the necessary supporter of combustion, or containing noxious gases, is strictly parallel to the delicate, sickly, etiolated appearance caused in human beings by an impure atmosphere, whilst the ultimate result is the same in both cases, namely, the extinction of vitality, or death.

An attentive examination into the phenomena of combustion, as exemplified in the burning of a candle, shows us, therefore, that not only is it necessary to take account of the food which we eat, that is to say, of the fuel with the combustion of which we keep up the requisite temperature; but that a careful attention to the quality of the air we breathe is no less important to our health and comfort. A candle burning in a close room not only consumes

a certain quantity of the vivifying principle of the atmosphere, diminishing the amount of oxygen present and available for other purposes, but it likewise communicates to the air an equal volume of another gas—carbonic acid,—a substance possessing the most deadly properties—the pure gas suffocating animals placed in it as if they had been plunged into so much water. Even when it is present in the air in only small quantities, it produces very deleterious effects, 4 per cent. acting like a narcotic poison in the atmosphere, and even a less proportion producing depressing effects of a most injurious description. If, then, a candle which consumes so small a quantity of oxygen causes such a change in the atmosphere, how much more will the respiration of human beings tend to vitiate it. It has been calculated that a man every twenty-four hours consumes nearly 400 cubic feet of air, with evolution of the deleterious carbonic acid gas; and that were he to be enclosed for twenty-four hours in a room eight feet square by nine feet high, he would be moribund at the end of the time. And these are not merely fanciful or supposititious cases. The action of contaminated confined air upon the health of the inhaler is one of the most potent and insidious causes of disease. Any addition to the natural atmosphere that we breathe must be a deterioration, and absolutely noxious in a greater or less degree. Our health, says Thackrah, would immediately suffer did not some vital conservative principle accommodate our functions to circumstance and situation. But this seems to get weaker from exertion. The more we draw on it, the less balance it leaves in our favour. The *vis vitæ*, which, in a more natural state, would carry the body to seventy or eighty years, is prematurely exhausted, and, like the gnomon shadow, whose motion no eye can perceive, but whose arrival at a certain point at a definite time is inevitable, the latent malaria, which, year after year, seems to inflict no perceptible injury, is yet hurrying the bulk of mankind with undeviating, silent, accelerating rapidity to a premature grave. Pure air is the food designed by nature for the constitution. Man subsists upon it more than upon his meat and drink; and there are numberless instances of persons living for months and years on a very scanty supply of aliment; but no one can subsist even for a few minutes without a copious supply of the aërial element.

Deaths from the respiration of many persons in a confined space are, unhappily, not rare; and without going back to the shocking instance of the Black Hole at Calcutta, we may refer to an equally lamentable occurrence which happened a few years ago in an emigrant ship, in which, during a storm off the English coast, the emigrants were confined below. In less than six hours more than sixty persons perished!

The paramount necessity which exists, according to these instances, for fresh air, equally holds good in less extreme cases. Just as surely as a total deprivation of oxygen, or the presence with it of any excess of deleterious gases, produces death; so the breathing of a partially-inhaled atmosphere is equally certain to occasion sickness and disease, if its inhalation be persisted in. The evils of exhausted air are also more to be guarded against, because persons can live in it without being aware of its danger, as far as their sensations are concerned. When we enter a crowded assembly on a cold day, the air is always at first repulsive and oppressive; but these sensations gradually disappear, and we then breathe freely, and are unconscious of the quality of the atmosphere. Science, however, reveals the fact, that the system sinks in action to meet the conditions of the impure air; but it does so at the expense of a gradual depression of the vital functions; and when this is continued, disease follows. *No disease can be thoroughly cured when there is a want of ventilation.* It is related, that illness continued in a family until a pane of glass was accidentally broken, and then it ceased: the window not being repaired, a plentiful supply of fresh air was admitted. Nearly all the churches in the empire require some artificial means of ventilation to render them physically fit receptacles for the body during a prolonged service. The Sunday-schools also, as a general rule, are *very ill ventilated;* and lessons in the second hour are far worse rendered than in the first, solely arising from a semi-lethargic coma that comes over the pupils breathing a carbonic air, which has already done duty and been inhaled by others several times. However much to be regretted, it is still true that people will sometimes sleep during the sermon. Now, the minister must not be twitted with this; for with the oratory of a Jeremy Taylor, or of a Tillotson, people could not be kept awake in an atmosphere charged with carbonic acid, the emanations of a thousand listeners.*

Instances innumerable might be pointed out in connection with our trades and professions, showing that no one can break with impunity the law of nature, which demands that the food destined to nourish and warm the body should be converted into heat, and vitalised by a constant supply of fresh and pure air. The importance of this subject becomes more evident if we turn to a few statistics. In a life of fifty years a man makes upwards of 500 millions of respirations, drawing through his lungs nearly 170 tons weight of air, and discharging nearly 20 tons weight of the poisonous carbonic acid. It has been also calculated that, to ventilate a room effectually, every person

* Piesse.

requires ten cubic feet of fresh air per minute*; a church, therefore, 80 feet long, 50 feet wide, and 40 feet high, and containing 1,000 persons, would require the whole atmospheric contents of the building to be renewed every sixteen minutes. A room containing a million cubic feet of air, in which were assembled 10,000 persons, would likewise require a total change every ten minutes; and an apartment twelve feet each way, with ten persons in it, would require an entire change of air every seventeen minutes.

This quantity of ten cubic feet of air per minute for each individual, is what is required to supply him with the amount of oxygen necessary for the performance of the functions of respiration; whilst the constant change of the atmosphere is imperatively necessary to get rid of the products of respiration, viz., the carbonic acid and aqueous vapour, as well as the effluvia from the body; for, disagreeable as it may be to refer to such a subject, this is the most noxious cause of contamination with which we are in the habit of coming in contact. "We instinctively," says Bernan, "shun approach to the dirty, the squalid, and the diseased, nor use a garment that may have been worn by another; we open sewers for matters that offend the sight and smell, and contaminate the air; we carefully remove impurities from what we eat and drink, filter morbid water, and fastidiously avoid drinking from a cup that may have been pressed to the lips of a friend. On the other hand, we resort to places of assembly, and draw into our mouths air loaded with effluvia from the lungs and skin and clothing of every individual in the promiscuous crowd: exhalations, offensive to a certain extent from the most healthy individuals, but which, rising from a living mass of skin and lung in all stages of evaporation, disease, and putridity, and prevented by the walls and ceiling from escaping, are, when thus concentrated, in the highest degree deleterious and loathsome."

The evils produced by allowing the carbonic acid from the breath to accumulate in the air, have been already mentioned; those engendered by inhaled animal effluvia are still more fatal in their results; for, according to competent authorities, it seems to be an invariable result that the accumulation and stagnation of the breath and perspiration of human beings crowded for a period in confined air, and neglecting personal cleanliness, produce plague or fever that may be communicated to healthy persons by contact or respiration. The most memorable

* This is the minimum which should be allowed. In the House of Commons, which is, perhaps, the most perfectly, as it is certainly the most scientifically ventilated building in the world, Dr. Reid never allows less than thirty cubic feet of air per minute for each member, when the room is crowded, and on many occasions sixty cubic feet have been allowed.

example of this is the Great Plague of London, which was caused by the total absence of proper ventilation in the filthy and overcrowded hovels in which the greater part of the poorer population of London lived, together with the filth and putrefying abominations which habitually filled not only the streets but even the houses of the lower classes. According to Bernan, the gaol fever was another disease which, arising from a neglect of the vital necessity for fresh air, was, a few centuries ago, an object of dread to society. The unfortunate and the criminal alike were immured in damp, cold, ill-aired dungeons, and kept in a state of inactivity. They inhaled the pent-up noxious effluvia emitted from their own bodies; and, from the want of means for personal purification, their clothes and bedding during their incarceration became saturated with the fatal exhalations. In this condition the miserable prisoners engendered, and became victims to, a disease of deadly malignity. They sickened, and with little apparent illness they died. The prison-house was thus the focus of a contagion that spread far and wide beyond its walls, and spared few who were so unhappy as to come within its influence. It was remarked, that although a prisoner happened to escape the infection, his clothes, nevertheless, emitted a pestilence that scattered death around him wherever he went. The assizes held at Oxford in 1577 were long remembered, and were called the *Black Assizes*, from the horrible catastrophe produced on that occasion by the gaol fever. Baker, in his Chronicle, tells us, that *all* who were present in court died in forty-eight hours—the judge, the sheriff, and 300 other persons!—so terrible was the retribution suffered by the community for its hardness of heart in denying to criminals even those personal requirements necessary for avoiding disease and preserving life.

Another similar catastrophe is recorded by Blaine as having occurred in 1750. During the sessions a sickening, nauseous smell was experienced by the persons in court, and within a week afterwards many who had been present were seized with a malignant fever. Among those who died were the Lord Mayor, the two judges, an alderman, a barrister, several of the jury, and forty other persons. It was remarkable that the prisoners who communicated the infection were not themselves ill of fever; and it was still more remarkable that none of those who were ill of it (to the greater number of whom it proved mortal) communicated it to their families or attendants, which showed that persons who were treated in clean and airy apartments, as those were who fell victims to it, do not communicate the disease to those in the constant habit of attending upon them.

Historians relate with just indignation that nearly three hun-

dred martyrs died at the stake in the reign of the bigot Mary. But how insignificant appear the number and sufferings of these victims of regal fanaticism when compared with the tortures of suffocation and death from stench, that were endured by thousands of persons in this and succeeding reigns, when every prison was a legal sepulchre.

Equally striking are the *good* results which have followed a judicious application of ventilation where it was formerly absent. It is scarcely possible to conceive a more repulsive and abominable state than that in which our ships of war were during the latter part of the last century, owing to the disregard, or rather the studied opposition, with which those then in authority treated all proposals to improve their ventilation. We regard other nations with whom we happen to be at war as our enemies, but a few figures, eloquent in their simplicity, will convince any one that incapacity, narrow-mindedness, or obstinacy in high places, are vastly more fatal in their results to our gallant sailors than the most formidable enemy they ever faced. In the year 1779 there were 70,000 seamen and marines voted by Parliament; of these 28,592 were sent sick to the hospitals, or 1 in 2.4. In 1784, of 85,000 men afloat, 21,371 were sent ashore sick within the year, or 1 in 4. But in 1804, when ventilation was partially, if not thoroughly, carried out in every ship, of the 100,000 men of which the navy that year consisted, 11,978 passed through the hospital, or only one in 8·3.

The evils of inefficient ventilation have been strikingly shown in the case of the Custom House, where the difficulty of ventilating a large public room has been very manifest. There the atmosphere in some of the apartments was so defective, as to produce general symptoms of ill-health among the officers whose official seats were placed in it. The functionaries were described to have had "a sense of tension or fulness of the head, with occasional flushings of the countenance, throbbings of the temples and vertigo, followed not unfrequently by confusion of ideas," that must be very disagreeable to persons occupied with important and sometimes intricate calculations. A few were affected with unpleasant perspiration at their sides. The whole of them complained of a remarkable coldness and languor at their extremities, more especially the legs and feet, which became habitual. The pulse in many cases was more feeble, frequent and sharp, and irritable, than it ought to have been. The sensations in the head occasionally rose to such a height, notwithstanding the most temperate regimen of life, as to render cupping requisite, and at other times depletory remedies; and costiveness, though not a uniform, was yet a prevailing symptom.

The identity between the combustion of a candle and that living kind of combustion which is ever going on within us has

thus been clearly exhibited. Like the candle, man depends for his life and vigour upon the chemical action exerted between the atmosphere and combustible matter; the combustion of the latter giving rise in each case to heat and vitality. Like the flame of a candle, too, man's health and strength languish and faint unless properly and uninterruptedly supplied with that mysterious breath of life—oxygen; whilst the feeble hold which the flame, even under the most favourable circumstances, has upon the wick, and the ease and totality of its extinction by the most trivial circumstance,—not only by a deprivation of air, but even by a puff of wind too much,—should teach us, even in our pride of health and strength, that our spark of life may be extinguished by the same causes, and our bodies may be left lifeless as a snuffed-out candle; the food—the combustible matter—may be there all the same; the oxygen may be in waiting, ready to combine with it; but the spark of fire, that spirit of life which man receives direct from his Creator, is absent, and without this all else is as nothing.

One more lesson from our candle, and we have done. What becomes of the human soul when it has left the body? What becomes of the flame when the candle is extinguished? Must our philosophy halt here? or will it turn round upon us and attempt to prove, in scientific jargon, that there is no such thing as a future? We think not. We believe that, as the relationship between the candle and man bears strict analogy from the first kindling of the mysterious vitalizing principle, through the varied phenomena of life, in sickness and in health, and even in the more mysterious phenomona of extinction,—so can the analogy be carried further into the dim shadowy realms beyond.

If there is one question more than another which has occupied the attention of modern philosophers, it is that relating to the *conservation of force*, or as it sometimes is called, *of energy*. It has long been admitted that matter can neither be created nor destroyed, and the whole tendency of modern discovery is now directed to show that *energy* is equally incapable of extinction. So long as it is exerting its action in a definite way, shining and glowing as a candle flame, evolving the *forces* of heat and light, we take note of it by means of our outward senses; but when the flame goes out, are these forces annihilated? Assuredly not. The energy which hitherto was occupied in the production of heat and light has only changed its immaterial form; it still exists in undiminished quantity, though it is now incapable of appreciation by our material senses. For just as the forces evolved by burning fuel are transformed into mechanical motion in the steam-engine; and just as mechanical motion is equally capable of being re-transformed into heat,

light, electricity, or chemical action,—just as every word we utter acting on the material atmosphere around us resolves itself into aërial waves of sound, which for ever afterwards vibrate with diminishing intensity, but expanding area, from one extremity of the atmosphere to the other, retaining always the same amount of energy as it did when the mechanical motion of the breath and lips first gave it birth,—so do the forces once born to activity when the candle is lighted live to the end of time undiminished in intensity, although changed in character. When the flame is naturally extinguished these living forces do not die, but become absorbed into that vast reservoir of energy which is the source of all life and light upon this globe.

And shall we then suppose that the soul of man is of less account than the flame of a candle? If philosophy can thus prove that the latter never dies, shall not faith accept the same proof that our own spiritual life is continued after the vital spark is extinguished?

# THE WEST COAST OF EQUATORIAL AFRICA.

BY THE EDITOR.

THE exciting stories of the gorilla-hunt, the description of "Fan" cannibals, naked, yet armed to the teeth, for we are told that they file their teeth to points to inspire terror in their enemies (and, we presume, the more readily to *masticate* them afterwards!), and the record of showers of ebony wives poured in upon the adventurous and favoured white traveller,* have but ill prepared the public mind for the reception of a sober working-day account of the western shores of Equatorial Africa.

Nevertheless, there are, doubtless, many whose curiosity has been awakened by these wonderful narratives, and who, desirous of becoming better acquainted with this portion of the world, will receive as welcome information a few leading facts on the subject, gathered from authentic sources, and published without embellishment. These it is our intention in the present brief essay to contribute.†

If the reader will refer to the annexed map, and will place his finger a little to the west of the Greenwich meridian, and about 5° north of the equator, he will find that it covers the British colony of Cape-Coast Castle, where civilization has already made sufficiently rapid strides to admit of the establishment of a newspaper,—the *West African Herald*, which disseminates valuable information concerning the condition of the western coast.

Moving eastward, he will have to cross the river Volta, which divides the two famous monarchies of Ashantee and Dahomey, the seats of a thriving trade in human flesh, and the dominions of potentates who do honour to their predecessors on the throne by digging pits "to contain human blood enough to float a canoe," and by filling them with the life-blood of thousands of their unoffending neighbours, whom they attack, capture, and slaughter for the "grand custom."

With these august potentates, her Majesty's government is vainly endeavouring to negotiate treaties for the discontinuance

* "Explorations and Adventures in Equatorial Africa." P. B. Du Chaillu. Murray. 1861.

† We are indebted for much of the information contained in this paper to J. A. Tobin, Esq., of Liverpool, who unreservedly, and with great kindness, placed at our disposal the whole of the correspondence of his firm with their agents on the West Coast of Africa. We have also received many valuable data from Alfred M. Power, Esq., of Liverpool, who resided many years in this part of Africa, and from other gentlemen engaged in the African trade.

of the odious traffic in slaves. His late majesty of Ashantee, although he said that he "beloved and respected the English character, and nothing afforded him such high satisfaction as to see an Englishman in his country and do him honour," could not consent to give up the slave-trade, "as it afforded him his chief means of revenue, and he held his power by the observance of the *time-honoured customs* of his forefathers."

The present ruler and his neighbour of Dahomey, both continue to carry on an active trade in human beings, despite the remonstrances of all civilized nations; and here it is that cannibalism, fetish-worship, witchcraft, and all the horrors of barbarism still reign uncontrolled, notwithstanding the efforts of missionaries, traders, and progressive civilization.

Leaving this land of promise, we shall request the reader to travel rapidly along the coast, which takes a bend southwards, and in so doing he will pass through Benin, and will cross what are commonly called "the Rivers;" namely, the mouths of the Niger, the Brass, Bonny, and Calabar rivers, and the river Cameroons. Here he may breathe with greater freedom under the assurance that the terrible slave-trade is giving place to a legitimate traffic with Europeans, chiefly in palm oil, but also in ivory, gold, ebony, &c., and (from Benin) in palm nuts, which yield a fine description of palm oil. Passing on, we leave to the westward the island of Fernando Po, a Spanish settlement; and travelling along the Bight of Biafra, the district concerning which Consul T. J. Hutchinson has recently published such valuable information,* we soon arrive at the Gaboon river, where it will be necessary to pause for an instant.

The banks of this river, and indeed the whole coast over which we have just travelled, are in the possession of native chiefs; but on the north bank is a French colony, and on this river a considerable trade is carried on between the natives and various European nations, in ivory, red and white barwood, ebony, india-rubber, beeswax, gum-copal, &c. &c. To the north and south of the Gaboon are the rivers Muni, and the Fernand Vaz and Nazareth, forming, according to Du Chaillu, the mouths of the Ogobai. To the eastward, from 100 to 200 miles inland, there run from north-west to south-east one or more ranges of high mountains, which extend with more or less regularity along the whole coast under consideration, and are called here the Sierra del Crystal. This is the region rendered famous by Du Chaillu, whose adventures have of late excited so much controversy; and here it is that the fierce gorilla, a gigantic anthropoid (or man-like) ape is said to roam,

* "Ten Years' Wanderings among the Ethiopians." T. J. Hutchinson, F.R.G.S. Hurst & Blackett. 1861.

the undisputed monarch of the wilds. To the west of the Gaboon river, in Corisco Bay, is the island of that name, where, as also on the mainland, the Americans have planted missionary stations, schools, &c.; and this is perhaps one of the most promising districts on the whole western coast.

Here the so-called "south coast" commences, and continuing southward we enter Loango, a country ruled by a negro king, where the odious slave-trade is carried on with all its concomitant horrors. Hurrying through this dark region, we reach the river and the territory of Congo, ruled by a number of petty kings, all owning allegiance to one great king, who resides at St. Salvador, in the agreeable proximity of the Portuguese, who have recently pushed their forces into the heart of his dominions, and erected a fortress in his very capital—St. Salvador.

Although the Portuguese have thus extended their colonies *inland*, the English government denies their right to occupy the coast, where they have attempted to levy duties upon our merchants, forcing them in some instances to shift their stores; and it is not until we arrive at the river Loze, or Ambriz, that we find them in undisputed possession of the soil.

From this point southward to about Mossamedes, the Portuguese colonies extend, and at the capital of *Angola*, St. Paul de Loanda, they have regular military and customs establishments. An excellent account of this place will be found in Dr. Livingstone's Travels, for it was here that he terminated, in the summer of 1855, his arduous journey across the African continent; and from hence he took his departure on his return to the opposite coast.

From St. Paul de Loanda and the neighbourhood, the chief produce exported consists of copper ore (malachite), palm oil, ground-nut oil, orchella-weed, pepper, camwood, barwood, ivory, coffee, and hides; and were it not for the difficulty in conveying merchandise to and from the interior, of which we shall speak hereafter, a very excellent trade would be carried on between this port and Europe.

Our journey is now at an end. From this point we might travel southward as far as Little Fish Bay, or Mossamedes, and still remain on the Portuguese territory; but having briefly noticed the various countries that constitute the coast of Western Equatorial Africa, we shall now direct our attention to those features of general interest by which it is characterized.

As a rule, the coast is flat, and in many places swampy; on proceeding inland, however, the land is found to rise, and at distances varying from fifty to two hundred miles, it becomes high and mountainous. From the Bight of Biafra almost to the Gaboon the shore is swampy and unhealthy (except in the proximity of the majestic mountain of Camaroons, which rises

above fourteen thousand feet over the level of the sea); but further south it is in many places skirted with cliffs.

The seasons on the coast* are threefold, and may be described in general terms as follows:—The three seasons are called *rainy*, *dry*, and *smoky*. It is difficult to state with exactitude when these seasons begin and when they terminate, for our authorities (some of whom have resided many years on the coast) do not all agree on the subject; but approximately the heavy rains, which are ushered in by tornadoes, last from about February to May or June; then cold, hazy weather sets in, and small drizzling rains prevail. This is the smoky season, which lasts until about September; and from that time until the rains re-commence early in the year, it is hot and dry, the thermometer averaging 83° in the shade. Strangely enough, however, the hot season is the most healthy; for it is during the smoky and rainy seasons that the fevers are most virulent.

The diseases to which Europeans (and, in a less degree, the natives) are subject, are, on their arrival, bilious and gastric fevers; then dysentery, agues, and yellow fever. The universal antidotes in cases of fever are large doses of quinine and emetics. Often, unfortunately, the patient has recourse to spirituous liquors, and it is hardly necessary to say that their deadly effects are sooner felt in this unhealthy region than in our own temperate climate.

If a casual reader tried to gather from the published works of travellers, or even from the conversation of friends who have resided on the coast, what is the general nature of the climate, he would find it very difficult to arrive at a satisfactory conclusion, for every one speaks "as he found it;" some describing it under the influence of sickness, after a weary journey, others having never left some one healthy spot on the coast; so that it is quite impossible to reconcile their ideas on the subject.

Both on the coast and in the interior, it is, as a rule, decidedly unhealthy and trying to Europeans, and will remain so *until the land is cultivated and reclaimed*. Nor is it to be wondered at, so long as bogs and mangrove swamps exist, that the miasma arising therefrom should breed fevers and agues. It must also be mentioned that, although there is generally a change of seasons, yet it not unfrequently happens that during eighteen months, there is not a single downfall of rain.† Under such circumstances, the streams dry up, vegetation decays, and, to use the expression of a resident, "the natives die like rats."

* This refers to the coast south of Cape Lopez. In the bights of Biafra and Benin the rains last from October to January, and the remainder of the year is hot and dry.

† From Cape Lopez southward there is sometimes not a single downfall of rain for twenty-four to twenty-six months!

The interior is not, however, so unhealthy as the coast, and not only is the air more salubrious, but here and there is to be found scenery of surpassing loveliness. Dr. Livingstone, and other travellers, have described many picturesque spots; and it may lend a little interest to our matter-of-fact inquiries, if we here introduce an extract from the letter of a gentleman formerly resident at Ambriz, descriptive of an interesting locality in the neighbourhood of that settlement. He had set out with a companion, on a visit to the "king" of Ambriz, and on their arrival at the village in which he resided, their attention was attracted by a high mountain near at hand. During their audience, they expressed a wish to mount the hill; but the king endeavoured to dissuade them from so doing, by relating horrible stories of the dangers they would encounter.* This, however, only sharpened their curiosity, and they determined to make the ascent.

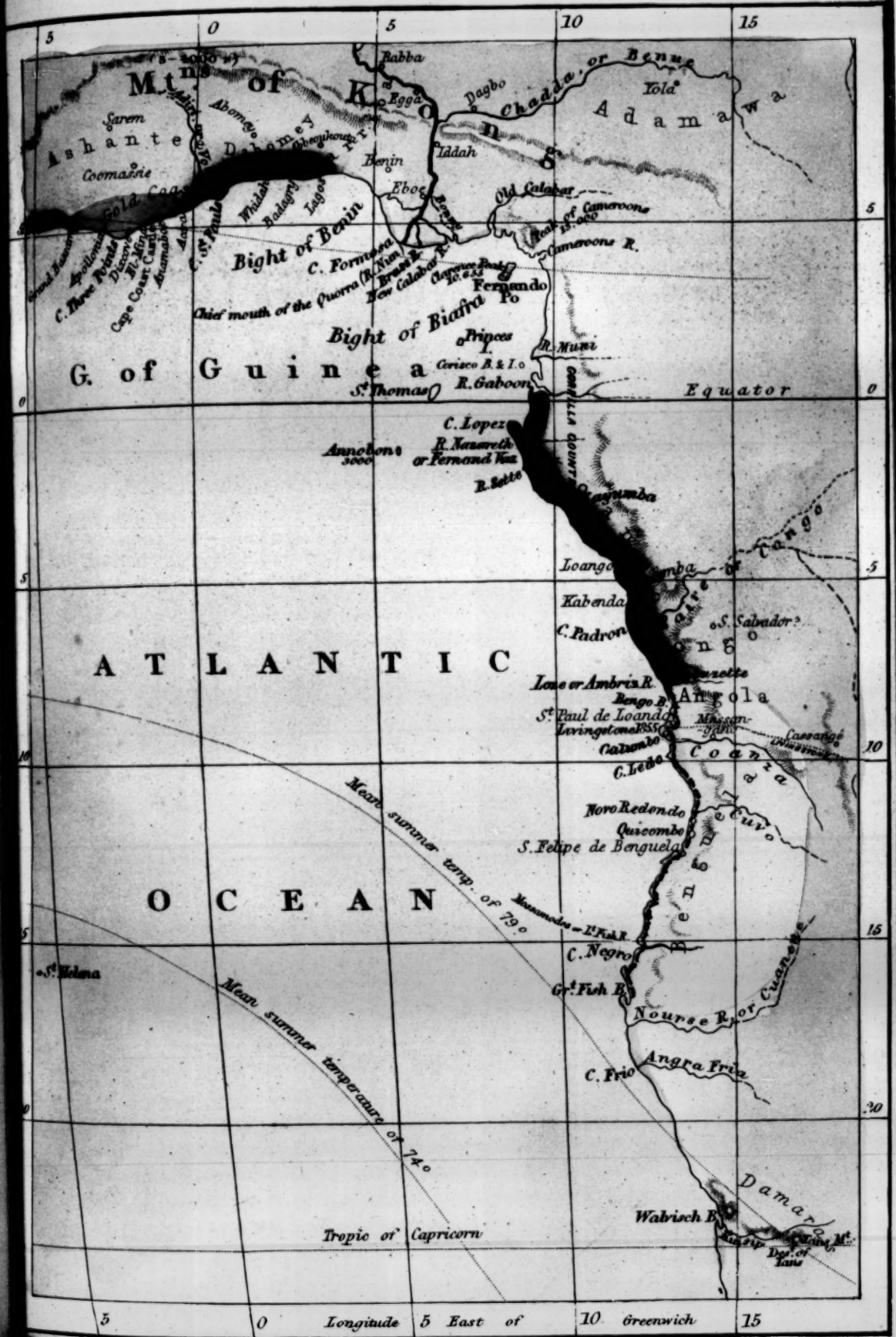
"We had no sooner declared our determination, than plenty of volunteers were ready to accompany us, and we soon found that there was no cause for fear. A tolerable footpath led right up to the top, and half an hour's climbing presented us with the noblest scene I think I ever beheld! Far down below our feet, almost immediately under us, was the river (Ambriz), which we now saw, for the first time, winding along, its banks verdant with corn and every production of a tropic clime; oranges and limes, cotton and sugarcane, all grew wild in great luxuriance. We could trace the river far inland, now hidden by trees, then again shining forth bright as a sheet of silver! It seemed not a continued stream, but a succession of small lakes, each one more beautiful than the other. Sometimes it was lost for a long distance amongst wooded hills, and then again we caught a glimpse of it afar off, till at length it was lost beyond a range of lofty mountains."

This description of the river Ambriz, or Loze, would almost carry one in imagination to the banks of the Rhine, or to some gentle slope in the English Lake district. We must now, however, pass from an attractive and pleasing topic, to a repulsive, but still interesting one; namely, from the smiling landscape to its degraded and unfortunate inhabitants.

We have no space to impart to this practical review even a shadow of romance, nor in any way to soften down the dark features that present themselves to our notice; and if the wonder-loving reader desires to hear negresses spoken of as "belles," or to see their picturesque head-dresses (formed of their own *wool*, intermixed with the *hair*, tail, and pieces of skin of the buffalo, and plastered with a cosmetic composed of palm-oil and white clay, scented with sweet-smelling rosewood!) we must refer him to the published works of Dr. Livingstone, and other adventurous travellers. But we have here to deal with the natives, as a trader or colonist finds them. On all

* A friend (formerly resident there) expresses the opinion that the "horrors" consisted of a slave barracoon.

# OUTLINE OF THE WESTERN COAST OF EQUATORIAL AFRICA.




...d from the most recent Authorities, by J. S.

Philip, Son. & Nephew, Engravers.

sides, from Englishmen, foreigners, and free men of colour, we hear but one opinion, modified indeed in its expression, but invariably the same in substance. "The negroes are an indolent, bad race;" they don't, and won't work; the women do all the field labour, planting mandioca (*Anglicè*, manioc, of which more hereafter), carrying heavy burdens, nursing, cooking,—in fact doing everything but "drinking" (and in many cases that also). The men eat, drink, fight, "palaver" (quarrel), and sleep. Of their horrible "fetish-worship," superstition, human sacrifices, and cannibalism, practised especially in Ashantee, Dahomey, Loango,* and other parts where the civilizing guns of the Europeans have not yet resounded, we have no room to speak; besides, enough has been *said*, and too little *done* to suppress these barbarities; but even where the temptations of gain have to some extent brought them within the pale of civilization, the African negroes are as bad as the worst of our European dealers, being the most unscrupulous traders to be met with on the face of the earth.

Although our information fully justifies us in making this sweeping assertion as regards the coloured men inhabiting this part of the world, we do not mean thereby to impugn the character of the whole race. Even in this region many honourable exceptions are to be found; and without at all referring to those who are in a state of servitude in America, or who have, through their education, been placed on a perfect equality with the white man, we shall, when we come to speak of the trade of the coast, be enabled to show that the honesty of the blacks might *in some instances* serve as an example to the more highly-endowed European.

Before passing away from this part of the subject, we must say a few words concerning the means that have been employed to reclaim this unfortunate branch of the human family. Of their wholesale deportation, by fraud and violence, to the plantations of Cuba, or wherever they may be consigned to servitude, little need be said; for the voice of civilized nations has declared this to be an unlawful act, and it is only a matter of surprise that it is not reckoned amongst the gravest of human crimes. Although the worldly condition of the negroes (at least, of such as reach their destination) may be somewhat ameliorated by the transference, yet the process is instigated by the most sordid motives, conducted without the smallest regard to humanity, and often accompanied throughout by horrors as indescribable as those enacted in the home of the negro.

* *Cannibalism* is not practised at Loango, but at Goanzo, up the Congo and in the district of Cape St. Braz, a little south of Loanda, Fetish-worship is prevalent along the whole coast.

Again, if we are to believe the testimony of truthful and disinterested informants who have resided years on the coast, the missionaries have, so far, produced little or no impression on the savage nature of the inhabitants. This arises chiefly from the degraded state of the natives, but also to some extent from the want of unanimity and the sectarian spirit prevalent amongst the missionaries themselves; each denomination representing its own as the only true Christianity. What may be the result of schools and missionary labours hereafter, it is impossible to say; and perhaps when their teachings are supported by something better than the trader's rum, and are no longer illustrated by a code of morals which can be studied to advantage on the quays of our large towns, their efforts may be more successful; but at present fetish-worship and human sacrifice are carried on as openly as the day when the missionary first landed.

From its human inhabitants we naturally descend (not a great way, however!) to the *fauna* of the coast and its vicinity.

The description of these alone would fill volumes; but our space will only allow us to name a few of the leading types.

Amongst the *Quadrumana* we find several large fierce apes, at the head of which stands the gorilla, a creature with whose appearance the world has been familiarized through the account given of it by M. Du Chaillu. Very little is, however, known of the natural history and habits of any of these interesting animals.

Bats are present in great numbers; and amongst the *Rodentia* we have several species of squirrel.

The leopard is the chief of the *Carnivora*, filling the place held by the lion and tiger in other parts of the tropics. It is accompanied in this group by the hyena, fox, &c.

Of *Ruminants* there is a great variety, the most characteristic being the wild bull, antelope, and gazelle.

But the most interesting, and by far the most useful, animals in this region, are found amongst the *Pachyderms;* viz., the elephant, hippopotamus, and wild hog; the two former yielding ivory and flesh-meat, and the latter affording a supply of food to the natives.

A word concerning the elephant. At present it is mercilessly slaughtered by the natives for the sake of its valuable ivory; but there is no doubt, that in so doing they are, to use a familiar expression, "killing the goose for the sake of the golden egg;" and if this animal should not have been exterminated before civilization has planted its foot firmly upon these barbarous shores, it will, doubtless, become as useful a beast of burden as it is in India, and will perform the labour at present imposed upon the women.

*Turtles, birds,* and *fish,* without number, frequent the coast, and no sportsman need here complain of a dearth of game.

The most useful, as well as the most graceful, of all the *Plants* of this region, is the palm-tree, which yields that great civilizing medium, palm oil; and hardly less important, as commercial productions, are the india-rubber vine, the barwood, ebony, and several gum-trees. The natives themselves, however, find less use in any of these than they do in the shrub variously designated the cassava, mandioca, and manioc (*Jatropha Manihot*), almost every part of which is a staple article of food. It, however, requires a considerable amount of preparation before it is fit for use, as the root contains a deleterious substance, which must be washed out before it can be dried, ground, and baked. Agriculture is quite unknown in most parts of this region, and the natives depend almost entirely upon the manioc for sustenance—this failing them, they die of starvation.

Added to the plants just mentioned, there are in Liberia and one or two other parts, small sugar-plantations, and, except in extremely dry seasons, the soil is capable of producing cotton,* coffee, cereals, and the fruits of temperate climates.

Of the *mineral* productions little is known. Copper, in the form of malachite, is received in considerable quantities from Loanda;† gold from various parts of the coast, but not to any extent. There is no doubt whatever that iron is plentiful. In the interior the natives employ it to fabricate spear-heads, knives, &c., and prefer these home-made productions to those they receive from European traders. Dr. Livingstone describes the ruins of an iron-foundry erected as far back as 1768, by a Portuguese nobleman, on the river Coanza, and states, that a party of native smiths and miners still work the rich black magnetic ore for the Portuguese government. The quantity of iron they produce is, however, inconsiderable.

Although there has never been any certain evidence of the existence of coal, there is little doubt that it will be found in considerable quantities, and in the neighbourhood of Ambrizette petroleum (mineral or rock oil) is very abundant.

It would be difficult to find anywhere a country better adapted for *trade* than this portion of Africa. Its rich tropical productions would furnish the materials for an enormous export traffic; its naked, unhoused, half-starved inhabitants would, if usefully employed, open a market for our home manufactures; whilst its numerous bays, creeks, and rivers, would afford the accommodation so necessary for a successful interchange of commodities.

* Dr. Livingstone found cotton further inland, and states that he purchased it at a penny per pound.

† The malachite is found at Ambrizette; but since the annexation of that place by the Portuguese, it has been conveyed to Loanda for shipment.

At Corisco, the Gaboon, Mayumba, Loango, Congo, Cabenda, Ambrizette, Loanda, Novo Redondo, Quicombo, Benguelo, Mossamedes, and many other places up and down the coast, vessels may ride at anchor in perfect safety, and some of the rivers are navigable for six hundred miles or more from the sea.

At present the trade is conducted in a very primitive manner, either on the deck of the vessel that conveys the home manufactures from Europe and returns with the raw produce of Africa, or in "stores" on land, superintended by resident agents of the European houses.

In some cases the traffic is carried on by direct barter, the natives bringing their produce to the store or trading vessel, and receiving in return a quantity of European materials; at other times, the captains, supercargoes, or agents, trust the more honest native chiefs and their subjects with various commodities, for which they are expected to supply within a given time a certain quantity of palm oil, ivory, &c.

A cursory examination of the articles employed in this trade will give us a better insight into the character of the natives than all the opinions that have been expressed concerning them. We find, for example, that spirits, tobacco, gunpowder, salt, silks, cloths,* beads, guns, &c., are *always* in demand; whilst knives, buttons, rods of brass and copper, caps, shirts, paint, oil, lamps, and *soap*, are usually more or less at a discount.

Never do we find rum to be a drug; never is there a glut of gunpowder! nor are paint and soap ever "in demand."

Then as to the native chiefs, many of them are grand seigneurs in their own way. From one of them (King Peppel), we find the following order to a Liverpool firm:—"Four dozen sherry, four dozen porter, four dozen ale, one small cask white bread, one box wax candles!" and we are informed that on some parts of the coast champagne, liqueurs, &c., are in great request amongst the chiefs.

The same articles which were in demand twenty or thirty years since are still in request; so that, excepting in some of the Portuguese and British settlements, the natives appear not to have made the slightest advance in civilization, save only as regards its vices and indulgences.

The evils of the "trust" system have, we believe, been very much overrated by travellers and others unacquainted with trade; for many of the largest houses declare that during the whole of their intercourse with the natives they have not lost ten casks of oil by this mode of conducting their business.†

* Used as a vestment round the middle; the only clothing that is worn.

† It is right to state that, in a report presented to the Board of Trade, Consul Hutchinson declares the trust system to be a vicious one.

A few words concerning the future of this region, and we have done.

A thoughtful writer on the subject* expresses himself completely at a loss to devise "some sort of education to root out the fell spirit" of this people, and thinks that "ages must pass by before any system can produce impressions of amelioration on temperaments such as they possess."

The *formation* of these habits has been the work of ages, and it is therefore probable that ages *would* elapse before they could be eradicated by any ordinary educational process.

Long before this can take effect, however, we venture to say that the soil will be in possession of the white man.

Meanwhile all the resources of civilization, trade, science, secular education, and religion, well supported by European arms, will be needed to reclaim the country and its inhabitants. Commerce has been, and will continue to be, the chief instrument of regeneration. The legitimate trade in produce will materially aid, as it has done, in suppressing the slave-trade; but before the former can be satisfactorily conducted, improvements in inland conveyance, by means of railways or tramways, elephants, and flat-bottomed boats upon the rivers, will have to replace the carrying trade as now conducted on the backs of women.

The monopolies of the coast tribes will also have to be broken through; but, in consequence of the jealousy of these, little hope can be entertained of any material improvement until the whole of the country has been brought under the subjection of Europeans.

Many of our readers will no doubt be startled at this assertion, and some, pointing to Liberia as an example of native rule, may protest against the theory of conquest. Whether or not Liberia is a "success" (for there is a great diversity of opinions on the subject), we cannot here decide; but certain it is that the great wave of progress will never be arrested in order to give time for the experiments of philanthropists; it will continue, as it began, to roll onward, preceded by the sword; but no doubt its progress will be characterized by the operation of expanding humanity and the appliances of the age.

Amongst these may be mentioned, as one of the most important and efficacious, the influence of the newspaper press.

Books, however useful they may be, are often written with an object, or, as we have seen of late, their contents are open to considerable discussion. However such works may please for the hour, they lose all practical effect upon the public mind, and their garniture familiarizes us with savage life, without inspiring

* Consul Hutchinson's "Ten Years' Wanderings among the Ethiopians," p. 79.

us with a sense of horror, with which we should be impressed by their perusal.

With journals, however, it is different. The African steamer arrives in Liverpool at night; and the next morning every statesman, man of business, and philanthropist, is informed at his breakfast-table that "the American and Portuguese slave-dealers are instigating the turbulent portion of the natives to quarrel with the British government on the coast, of which they will no doubt take every possible advantage to push the slave traffic;" or that "the king of Dahomey was sending down large droves of slaves to Whydah, and that there was no doubt entertained but that they would all be got off safe."*

Whatever doubt may have been expressed concerning "tales of travellers," no one will call into question the matter-of-fact information disseminated by the Press; and we trust that this mighty engine will soon be in full operation wherever Englishmen, Portuguese, Spaniards, or Americans, have planted their feet on African soil, and that its influence, combined with those already named, will soon transform the region which we have brought in so imperfect a manner under the notice of our readers, from a land of barbarism, desolation, and misery, to one of peace, plenty, and happiness.

* *West African Herald*, 29th April, 1861.

# THE GREAT COMET OF 1861.

BY JAMES BREEN.

ON the night of June 30th, astronomers and the public in general were astonished by the appearance of a large and bright comet in the northern heavens. Those who saw it on that and the following few days, and who remembered and compared it with the other great comets of the present century, confessed that they had never seen anything so brilliant. Sir John Herschel, the Nestor of modern astronomers, writes, that "it far exceeded in brightness any I have before observed, those of 1811 and the recent splendid one of 1858 not excepted. It preserved the same magnificent appearance up to the 5th of July; but after this date it diminished greatly in size and lustre, although still a conspicuous object in the heavens. Even as late as the 17th of August I was able to see it with the naked eye.

No sooner had a sufficiency of observations been taken of the stranger, than astronomers set to work to discuss whether it was the great expected comet of 1264 and 1556, of which we had been promised a view for some years past. These bodies, as every one is aware, are supposed to have been one and the same; and not only are they celebrated on this account, but likewise for the historical events connected with their appearance. If we are to believe the ancient chroniclers in respect to the comet of 1264, it would seem that Pope Urban fell sick the very day the comet was first noticed, and died exactly on the day it disappeared! One old chronicler, bearing the somewhat appropriate name of Funckins, indeed mentions a quantity of supplementary mischief which it did on this occasion, in the shape of wars, plagues, drying up of springs, &c.; but the death of the pontiff was considered as the principal purpose of its mission to the earth. In 1556 it is said to have caused the abdication of Charles V., who, on seeing it, repeated the well-known sentence, "*His indiciis me mea fata vocant,*" and retired to a monastery.

The new-comer turned out, however, to be quite a different object from the mysterious body which exerted such a baneful influence on crowned heads. The comets of 1264 and 1556 cut the ecliptic at 175° of longitude; whilst the longitude of their least distance from the sun was about 280°. The inclination of their orbit to the ecliptic was only 30°, their least

distance from the sun was 44 millions of miles, and their motion was direct. These quantities, which determine the path of the comet round the sun, are altogether discordant with those given by the wanderer of June, 1861. According to my calculations, which agree with those of others, the longitude of the ascending node of the latter was 278° 59′; that of perihelion, 249° 15′. The inclination of the orbit to the ecliptic was 85° 39′; whilst its least distance from the sun was 78 millions of miles. The motion was direct. It will be seen from this, that we must yet be on the look-out for the comet of 1556, in case it has not already passed away unnoticed, a supposition which is becoming more and more probable every day.

Although, however, we were not fortunate enough to witness the reappearance of those celebrated historical comets, yet there were other circumstances connected with the present object which were scarcely less marvellous. From the calculations of Professor Hind, it would seem possible that the earth passed through the tail of the comet on the afternoon of June 30th, and an unusual glare in the sky was noticed by himself and several others on that evening, which was attributed at the time to an auroral light. When it is remembered (according to the calculations of the astronomer Olbers) that the probability of the earth coming into collision with the atmosphere of a comet could only occur once in 8 or 9 millions of years (the probability of the earth coming into collision with the *nucleus* of a comet, he calculates could only occur once in 220 millions of years), we may conclude, within fair limits, that nothing of this kind has occurred since the creation of man. Had such an event been prognosticated, the terror which would have ensued may be easily imagined; nor would it have been altogether dissipated even if we took the more favourable views of the astronomer Pape, who computes that the distance of the tail of the comet from the earth was at least $2\frac{1}{3}$ millions of miles on this occasion. We once heard St. Marc Girardin repeat a *mot* of M. Babinet, who asserted that the shock which the earth would receive from collision with a comet would be no greater than that received by a locomotive in full speed meeting with a fly. But the fly in this instance might cause as much alarm as the spider in another, of which the poet says—

> "There may be in the cup
> A spider steeped, and one may drink; depart,
> And yet partake no venom; for his knowledge
> Is not infected; but if one present
> The abhorred ingredient to his eye"—

the case would be different, especially when the poisoned atmosphere of a comet might be expected to mingle with and

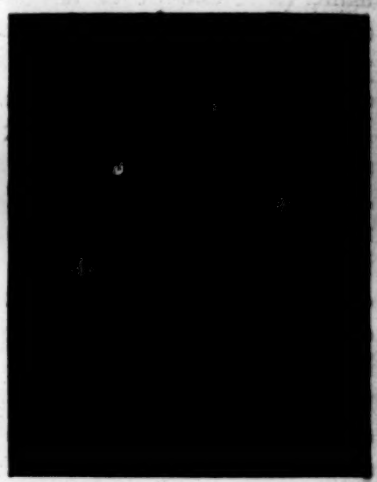
be diffused over the earth, according to the wild imaginations of Poe.

The telescopic appearances of the head and nucleus of the present object, although very remarkable, did not show the same extraordinary changes as were perceived in Donati's comet of 1858. We give a representation of the fan-like appendage proceeding from the nucleus, as taken by Mr. Wray on July 4, which, considering the excellent means at his command (a telescope of seven inches aperture), and the keenness of his vision, may be considered as the best view of the comet yet published. Mr. Wray states his surprise at the comparative constancy of the phenomena of the luminous sector over that of Donati's and other comets, it remaining nearly of the same size and brilliancy, and in the same direction, during the month of July. Sir J. Herschel states that on the night of June 30 the nucleus was very much condensed; and on the night of July 2 it was concentrated into a dense pellet of about 300 miles in diameter, but no unequivocal symptons of a fan could be perceived. Although the luminous sector could not be perceived by the illustrious astronomer on the evening of the 3rd, yet on the early morning of the 4th it was certainly seen by several observers, and was very apparent in a telescope of five inches aperture belonging to J. Buckingham, Esq., C.E., with which I observed. On the evening of the 4th and 5th it was most beautifully visible; but instead of the appearance which it presented in Donati's comet, viz., that of looking through a partially transparent and hollow dome, the aspect was comparatively irregular, and the luminous jets and branches proceeding from the nucleus bore some resemblance to a pyrotechnic display. Those remarkable "hoods" of cometic matter which I saw in Donati's comet, in 1858, with the great Northumberland telescope at the Cambridge Observatory, and which were successively passing away from the nucleus, as beautifully described by D'Orsay in the Chancellor's Prize Poem of 1860, were wanting in the present instance :—

"Next rose to view a startling change of scene;
Round the bright nucleus waved a concave screen;
And radiant hoods, pure envelopes of light,
In slow succession gleamed upon our sight.
Volumes of lustre from the star disc came,—
Fold within fold, each marvellous coat of flame!
Watch the sharp throes of that tremendous birth,
As if the molten mass that fills our earth
Had burst its boundaries, fired and flung on high
The crust men call a continent; the sky
Blazing with light from each strange hemisphere,
Which sunward hurries in its swift career.
So in yon nucleus some explosive force
Launches each concave on its fiery course;

Arch above arch, aurora-like, they rise,—
Concentric canopies, cometic skies."

Mr. Wray noticed that the branches, or jets, proceeding from the nucleus alternated in brightness. The apparent left spur, marked A (as seen in an inverting telescope), which was very bright on July 4, afterwards became almost invisible, the others remaining nearly of the same lustre. On July 11 the head, which had hitherto been of a regular parabolic figure, became



narrower as it joined with the tail; the part B in the sketch (which was taken with my telescope of $3\frac{3}{4}$-inch aperture), was much brighter than the opposite side, and slightly convex.

The remarkable increase in the length of the tail between June 30 and July 4 may be considered as astounding, even in this marvellous class of objects. Sir J. Herschel considered the length of the tail on the former evening as 30°, which, at the then distance of the comet, would be about $6\frac{1}{2}$ millions of miles in length. On July 4 he considered it as 80° in length, or the actual length would be about 27 millions of miles! The phenomena which were going on within the canopy of flame termed the luminous sector, or fan, were, it is true, on a less gigantic scale; but what prodigies of creative force and energy were even there evoked!—the "pellet" of concentrated light (as it was designated on June 30), called the nucleus, a few days later throwing up mighty columns of nebulous matter towards the sun, forming a dome of inconceivable girth (some 35,000 miles from the spot it sprung from and enveloped), and then flowing silently backwards and adding millions of miles to the milky train following the meteor. We can only imagine some cloud-like formation of extreme tenuity to be capable of these sudden changes, and even then under the influence of some overpowering force.

It may be mentioned, in conclusion, that no signs of polarity could be perceived in the light of the comet, although experimented on with the most delicate instruments by Sir John Herschel. Neither could the slightest image be perceived on a highly-sensitized collodion plate, although Mr. De la Rue, who endeavoured to procure it, was able to obtain it in the case of Donati's comet of 1858.

The comet is still visible in the northern heavens, although, from its great distance from the earth, powerful instruments must be used in order to catch a glimpse of it. Its distance on Sept. 28 is 205 millions of miles, and it is situated at R. A. 16h. 9m., and 48° 14′ of north polar distance, according to the foregoing orbit which I have calculated.

# REVIEWS

## AND SHORT NOTICES OF BOOKS.

### THE PAST AND PRESENT LIFE OF THE GLOBE.*

THE history of man's dwelling-place must always be to him a subject of deep interest, not only in so far as it concerns the beneficent designs and operations of the Creator in preparing it for his reception, but also as a guide in his speculations upon the probable future of his race.

Our readers are, doubtless, well aware that there are various theories with respect to the changes that took place in the earth's crust, and in the nature of the living forms upon its surface, before the advent of man,—theories that have been unwisely debated, with considerable acrimony, in consequence of their bearing upon matters connected with theological belief. Some of the students of the earth's history entertain the conviction that the strata which constitute its external crust were formed at distinct intervals, succeeding one another, and that between each such interval there was a violent "cataclysm" (literally a "washing down"—a deluge, in fact), which destroyed all living organisms, animal and vegetable, then existing upon its surface, and that a completely new creation followed this violent disturbance in nature. This theory of successive destructions and re-creations, as it were, finds favour with those who adhere to the literal interpretation of the Book of Genesis, and the *last* creation they believe to have been the one referred to in the first chapter of that book. On the other hand, there are those who believe that nature has been pursuing a steady and uninterrupted course for ages of ages, and that, with the exception of local eruptions, earthquakes, and deluges, such as we have known within the historic period, the changes in its surface have been the result of gradual depositions in its seas and lakes, and the slow subsidence and upheaval of its continents and islands. These observers believe that there has never been a decided break in the development of the vegetable and animal kingdoms, but that, affected by various causes, such as changes in climate and the conditions of the surface, they have gone on improving, not in the sense of becoming perfect, for all plants and animals have been perfect in their adaptation to the external world by which they were surrounded, but rising in the variety and complexity of their organs and functions.

Then again, such of our readers as have been induced to take a deeper interest in these questions, will know that amongst the advocates of the theory of gradual development, there are some who believe that *each new species* has been a distinct creation, that is, the result of a direct miraculous

* "The Past and Present Life of the Globe." By David Page, F.G.S. William Blackwood & Sons.

interposition of the hand of Providence, which has from time to time, in accordance with the changing conditions of the earth's surface, and a preconceived design, created new types of animals known to us as *species*; whilst others are of opinion that no such interposition has taken place, but that through the operation of an unknown law, one species has been converted into another, and a higher one, during the development of the *embryo* of individuals; and a third set of observers, following the doctrines of Mr. Darwin, attribute the variation of species to *external* physical causes, namely, they believe that it is owing to the capacity possessed by some individuals, of adapting themselves to the changing physical conditions by which they were surrounded. This capability is believed to have arisen from some accidental modification in their external or internal structure, not of sufficient value in any one individual to mark it as a distinct species or even variety, but a peculiarity which, accumulating in succeeding generations, caused the possessors at length to assume a different type, and become *first specifically*, and at length *generically* distinct from their ancestors. Such animals as did not possess these peculiarities that fitted them for the "struggle for existence," naturally died out (according to Mr. Darwin's theory), and gave place to their more fortunate congeners.

As before stated, the theory of repeated destructions and re-creations has been referred to by some theologians, as corroborative of the biblical account of the earth's creation; and now we have to add that the theory of progressive development, *when taken apart from any immediate interposition of the Creator*, has been eagerly seized by the so-called atheists, as evidence in favour of *their* tenets. It is, therefore, not to be wondered at, if the discussion of these opposite theories should often have been conducted in an uncharitable spirit, certainly, however, without the slightest show of justice or reason; for a reference to the opinions of naturalists reveals the fact that they have been held quite irrespective of theological belief; some, whose views are materialistic, still advocating the theory of repeated cataclysms; whilst many who are in other respects completely orthodox, are to be found amongst the strenuous partizans of the theory of progressive development through secondary causes. The majority of good and thoughtful men, however, are beginning to regard the question from a different point of view, and to bestow upon it their dispassionate attention.

Divested of all its exaggerated features, the history of the past and present life of the globe is full of romantic interest and instructive lessons; and instead of serving, as it has done, as a bugbear to the ignorant, and a bone of contention to rival theologians, it is in reality one of the most important problems presented by the Deity for the exercise of man's noblest faculties, and as such we recommend it to the consideration of our readers.

Mr. Page's book leads the novice (or even the well-informed reader) through the present life of the globe back into the distant past and, in comparatively speaking popular language, relates its story up to the historic era.

He never wanders into speculations, nor does he, on the other hand, leave out of account the most recent and still-debated discoveries; indeed, as long as his account is *narrative*, he is, as he wishes to be, faithful to the task he has undertaken, and has fulfilled it in an accurate, agreable, and reverent spirit.

Although equally desirous to be unbiassed in his review of the opinions of others, he is here not so successful; for whilst he lays it down as his opinion that all earnest thinkers are not only entitled to a fair hearing, but that without the expression of their varied theories and even hypotheses, we should never arrive at the truth; and whilst, in one place, he declares that "science has its own line and limit of inquiry" (irrespective of theological belief), yet, in another part, where his views are at variance with those of other inquirers, he cannot refrain from stigmatizing the latter as "materialistic," and censures them for not introducing the religious element into their investigations!

We merely mention this as a proof how difficult it is, even for those who do not wish to be regarded as partizans, to lay aside the theological *animus*, and as an example to be avoided by those who approach the subject with a wish to derive full benefit from their inquiries.

On the whole, however, the author deals with the subject in a fair and impartial manner, and we recommend all who desire, without much effort or expenditure of time, to become acquainted with the history of the globe and its living denizens so far as it is at present known, to consult the pages of this able and interesting work.

They will find its *style* popular, the more abstruse technical terms being in every needful case explained; the *illustrations* accurate, artistically drawn, and well engraved; the *type* clear, and free from errors, agreeable to read, and in harmony with the other adjuncts of the volume.

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## A GOSSIP ABOUT DOGS.*

BY E. JESSE, F.L.S.

WHO will not be interested to hear fresh tidings concerning man's faithful companion amongst the lower animals? Every housekeeper, every sportsman, every child, knows his worth and can afford him a share of his affection.

The propensity which dogs have to attach themselves to man is a remarkable circumstance in the character of this animal. Poverty, sickness, absence, and even unkindness and neglect, do not diminish the love and fidelity of the poor dog to his master. When Stanislaus, the unfortunate king of Poland, was writing to his daughter, he told her that Tristan, his companion in misfortune, licked his feet, thus showing that he had still one friend (his dog) who stuck to him in his adversity. Sir Walter Scott said that he would believe anything of a dog, and indeed their sagacity, extraordinary aptitude in learning not only tricks but to obey the wishes of their masters, their fidelity, courage, and watchfulness, fully entitle them to this compliment. That some dogs have greater sense and qualities differing from others need not be doubted. Some will learn readily—others not at all. Let us give an instance of this. A lady had a pretty spaniel. She tried repeatedly and indefatigably to teach him to beg, but all her efforts were in vain. One day her cat,

* "House Dogs and Sporting Dogs," by John Meyrick. Van Voorst.

which was apparently asleep on her rug near her, placed herself by the side of her stupid dog, and showed him what he was required to do by begging herself. Here was sense contrasted with a want of intelligence. This is a curious anecdote, and it is a perfectly true one.

The book before us contains more useful hints for the management of dogs, both in the field, the house, or the kennel, than any similar work we have yet met with. It contains also some interesting facts on dog-stealing, which may be of use to those who may chance to lose one of these faithful animals.

It would appear that the most careful watching on the part of the owner will scarcely prevent a dog being stolen in the streets of London. If he takes his eyes off his dog for a moment, he finds that it has disappeared, and in this way. Two thieves are in league. One walks about fifty paces ahead of the owner of the dog, and drops small pieces of boiled liver called "duff." The dog naturally lags behind his master to eat it, when the second thief, generally dressed as a respectable mechanic, with an apron, catches him quickly up, covers him with his apron, and coolly walks by the owner, who, when he misses the dog, never dreams of suspecting anyone who is not running away.

A dog is not safe from dog-stealers even if he wears a chain and collar, if he is entrusted to a careless person. A gentleman had a valuable dog, which had been twice stolen and brought back, and which his master determined never to trust out of the house again without a chain. He was one day, however, sent out to walk with an Irish servant, who came back without him, declaring that the dog had slipped his head through the collar when he was not looking. The dog was in a few days brought back, and his master again ransomed him, making it a condition of his doing so that the thief should tell him how the dog had been stolen. It then appeared that his servant had stopped to look at some of his countrymen mending the street, and, while so doing, one thief had held the dog's chain with one hand to imitate the pulling of the dog, while with the other he undid his collar, wrapped him in his coat, and then pointing to his companion, who ran away, he told the servant that the fellow had just stolen his dog, who, of course, pursued him, leaving the animal in the possession of the other.

The writer of this article had a favourite terrier called "Peter." He brought him with him to a house he had taken in Lower Berkeley Street, Portman Square, in a close carriage, the dog never having been in London before. While the servant was unloading the carriage the dog was missed, and nothing heard of him for more than a fortnight, although handbills were circulated offering a reward for him. At the end of that time the dog rushed into the house, jumped up to his master, and showed every sign of joy. He, however, looked thin and starved, and had a piece of cord attached to his collar. He had evidently escaped from the dog-stealers, but how he found his way back to a house he could only have been in for a moment is not easily to be accounted for.

Perhaps amongst the different breeds of dogs, the Scotch colley, or sheep dog, bears away the palm, whether for intelligence, patience, or fidelity. For instance a colley in the Highlands of Scotland was left in the solitary charge of a flock of sheep, which were feeding in a field separated only by a ruined

wall, full of wide gaps, from a field of young corn. The dog had for some time taken his stand on a hillock, from whence he could overlook the whole field, and check any attempt of the sheep to intrude on the cornfield. He remained patiently and watchfully at his post from the earliest dawn to nightfall, and brought the flock home in the evening on hearing the shrill whistle of his master, who lived nearly a mile off. Must we not admire the extraordinary intelligence and the strict sense of duty shown by this faithful animal?

We might multiply similar examples to a great extent; but let us conclude this notice of the colley, by supposing him to have been the constant companion of some old shepherd through many a weary day of rain and frost and snow, on the neighbouring hills, gathering the scattered flock with persevering industry, and receiving the reward of his exertions in the approbation of his master. On returning to the humble cottage at night, he partakes of the "shepherd's scanty fare," and then, coiled up before the flickering light of a few collected sticks, cold and shivering with wet, he awakes to greet his master at the first glimmering of morn, and is ready to renew his toils. Poor dog!—it is impossible not to love and admire you.

But we have not space to enumerate the different breeds or varieties of dogs. Our author notices very many of them; but the chief value of his book consists in his hints for the proper management, training, and breeding of them. In these respects the work is invaluable, and also his receipts for curing or preventing the diseases to which dogs are liable; we can, therefore, safely recommend Mr. Meyrick's work to the attention of our readers, feeling sure that it will equally gratify and instruct them.

The work is nicely got up, the *type* clear and pleasant to read, and the *binding* plain and strong. Of the *illustrations* we can say nothing, for they are "conspicuous by their absence," a circumstance to be regretted, for a few good woodcuts of the various breeds would have added considerably to the interest of the work.

We cannot close this notice without expressing our obligation to Mr. Van Voorst for his great exertions in the cause of natural history; for he has done as much to promote its progress as the able authors who have addressed the world through his medium. Who can forget Yarrell's "British Birds and Fishes," Bell's "British Quadrupeds and Reptiles," Forbes's "British Starfishes," Selby's "Forest Trees," and Newman's "Ferns and Insects?" These, with many others, too numerous to be mentioned, will remain as mementos of his successful labours as a publisher long after he has passed from amongst men. We could say much more in his praise, and we feel sure that these few words of recognition will meet with a hearty sympathy amongst our readers, to whom his excellent works are known.

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*Chemical History of a Candle.* By Professor Faraday. Edited by William Crookes, F.C.S. Griffin & Co.

Intended for young beginners, for whom it is well adapted, as an introduction to the study of chemistry.

*Practical Chemistry.* By J. E. Bowman, F.C.S. Edited by C. L. Bloxam. Longman.

This book is, strictly speaking, a "Manual of Chemical Analysis," and not a work on "Practical Chemistry." It is suitable for teachers, who will find it valuable in the preparation of lectures. Those who wish to employ it for self-tuition will only be able to avail themselves of the first and second parts for that purpose.

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*Iron: its History, Properties, and Processes of Manufacture.* By William Fairbairn, C.E. &c. Black.

Professor Hunt's paper on "Iron and Steel," in the present number, may serve as an introduction to this useful little volume. Although of a somewhat technical character, it is by no means dry reading, is well illustrated, and contains a large amount of valuable information concerning the most useful metal employed by man.

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*In-door Plants, and how to grow them.* By E. A. Maling. Smith, Elder, & Co.

Ladies of taste, who desire to adorn their homes with the beautiful productions of nature, will find this little book useful in aiding them to do so at a small cost.

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*Wild Flowers worth Notice.* By Mrs. Lankester. With Illustrations by J. E. Sowerby. Hardwicke.

Mrs. Lankester has produced a volume which will be found of service to young beginners in the study of botany; and Mr. Sowerby has rendered it most attractive by his well-executed illustrations. One feature of special interest is the information which it contains on the uses, as well as on the distinguishing features of the plants described.

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*British Birds' Eggs and Nests, popularly described.* By Rev. J. C. Atkinson. With Coloured Illustrations by W. S. Coleman (accompanied by a "Synoptical Table of British Breeding-Birds, Nests, and Eggs"—(323 in number). Routledge.

An elegant volume, very beautifully illustrated — will be appreciated by collectors of birds' eggs, and may be read with profit by those who desire to know something of the ornithology of this country. But the style is defective, and, we regret to say, somewhat characteristic of the careless one which very many of the scientific writers of the day consider themselves licensed to adopt.

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*Sea-Side Divinity.* By the Rev. Robert W. Fraser, M.A. Illustrated by Humphreys, Wolf, Andrews, &c. Hogg & Sons.

Is *not* a collection of sermons as the title would indicate; but a business-like account of the geology, botany, zoology, and meteorology of the shores of Great Britain.

*Lectures on Natural History.* By E. Jesse, F.L.S. L. Booth.

This little book is what Mr. Jesse no doubt intended it to be—a gossip on several subjects connected with natural history. It is published with a very praiseworthy object, viz., for the benefit of the Brighton Sailors' Home, and deserves a large sale. Young persons of both sexes will find it very interesting.

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*Marvels of Pond-Life.* By H. J. Slack, F.G.S. Groombridge.

"Is intended to be no more than an introduction to an agreeable branch of microscopical study," and as such, will interest many who go in search of animalculæ.

Works of this kind are now so plentiful, that it is time for popular microscopists to employ their pen in the description of one or two forms at a time; illustrating it with accurate drawings of the detailed structure of the objects described, instead of grouping together a large number in one small volume, and repeating what has been said concerning them fifty times before.

We do not say this to disparage Mr. Slack's efforts, but to show him how we think he could make them more acceptable to the general reader. The work is nicely got up, and the illustrations are very creditable to the lady who has executed them.

# MISCELLANEA.

## THE LIVERPOOL AND MANCHESTER FIELD NATURALISTS' SOCIETIES.

IT would be difficult to decide which of the two is effecting the greatest amount of good—the "Manchester Field Naturalists' Society," or the "Liverpool Naturalists' Field Club."

Neither has yet terminated the second year of its existence, and already the Manchester Society numbers over 400 members, whilst the Liverpool Club boasts of considerably more than 500. One of the chief causes of their rapid rise and great popularity is the admission of lady members to all their meetings, whether in the open air or in the lecture-hall.

We cannot, in this our first notice, treat in detail of the operations of the societies, but the salient features will be gathered from the following narrative of a meeting which took place by arrangement between the members of the two clubs, at a fine old ruin called Hoghton Tower, near Preston, Lancashire, on Saturday, July 20th. On this occasion, the weather being fine at Liverpool and rainy in Manchester, about 300 members and friends constituted the party from the former place, whilst scarcely more than 40 persons (the most zealous workers, of course) set out from Manchester, and both parties arrived at the rendezvous at about three o'clock in the afternoon.

Here the weather was beautiful, though at first a little dull, but by the time that the leaders of the two societies had exchanged courtesies on the slope of the hill, the sun shone warm and bright, and the atmosphere became as calm and transparent as could be desired. After enjoying the view from the Tower, and some botanizing in the woods behind and below it, on the part of the ladies and a few gentlemen, led by Mr. Grindon, the honorary secretary of the Manchester Field Naturalists, the whole party assembled for tea, the leaders of the Liverpool club—Rev. H. H. Higgins, M.A., and Rev. William Banister—having kindly remained to see that all preparations were duly completed. Tea concluded, all who felt so disposed adjourned to the green slope in front of the Tower, where Mr. Grindon soon drew around him a large company, and proceeded to deliver an address upon the principal plants which had been collected during the day. He stated that it was the custom with the Manchester Field Naturalists always to have such an address, by way of impressing the results of the day's researches, and giving an agreeable finish and consolidation to the objects of the excursion. Drawing attention, in the first place, to the *Ferns* which had been gathered, Mr. Grindon showed that most of the large and common species, while in their very young state, so closely resemble mature fronds of small and rarer kinds (except that they are destitute of fructification), that beginners are extremely liable to be deceived by them.

He warned collectors not to suppose that because they had got a lovely *little* fern, it must needs be one of the gems of the fernery, for if placed there, in a short time it would in all likelihood overshadow everything else. Specimens of *Polypodium phegopteris* being handed up, the lecturer remarked that this plant was often supposed, from its name of *Beech*-fern, to be a lover of beechen woods, just as the *P. dryopteris*, or *Oak*-fern, is commonly supposed to be so called by reason of a preference for the shade of oak-trees. Both ideas are mistaken ones. The ferns are respectively named after the two trees because in profile or general outline the individual fronds bear a striking resemblance to the profiles of the beech and oak; so that in those landscape pictures which are often prepared by gumming down mosses, lichens, and ferns, in such a way as to resemble forests and other elements of rural views, these two, the *Phegopteris* and the *Dryopteris*, become striking and ready-made drawings of the respective trees. In the living state, the resemblance of the *Dryopteris* to the oak-tree is somewhat impaired by the deflexion of the central branch, but this is no longer perceived when the frond is laid flat. The *Wild Raspberry* was the next plant noticed. Mr. Grindon commented on the interesting fact that it was probably the only one of our native fruits which in the wild condition has often as good a taste as when cultivated. The apple begins in the crab, the plum begins in the sloe, the cherry in an austere and almost juiceless globule, not larger than a pea; but the raspberry is a raspberry from the commencement. In the woods and cloughs of South Lancashire it is exceedingly abundant, and large quantities of excellent fruit could be collected where the raids of town lads allowed it to ripen. Near Bristol the raspberry is a rare plant; and while walking once in the forest of Meudon, near Paris, the lecturer said he was again struck by the absence of it, made noticeable by the profusion of the wild red-currant, by which the old accustomed fruit was superseded. Describing the *Circæa*, or Enchanter's Nightshade, and some other plants with names suggestive of classic story, the lecturer pointed out the great variety in the pleasures opened up to all intellects by the study of botany, which was not to be deemed the art of flower-slaughter and excruciating nomenclature, but rather as the "Gate Beautiful" both into Nature and into very much of the best portion of poetry, literature, and mythology.

Various specimens, gathered by different members, being placed in Mr. Grindon's hands to be named and described, the lecturer spoke after the same manner respecting the Wild Heath, dwelling especially on a branch of the common heather, or *Calluna vulgaris*, a plant loving great solitudes. He called attention to the vast number of individual blossoms that were crowded together into the small space it offered, and to the pretty arrangement of the minute leaves, which were disposed in such a way as to remind us of some of the patterns of ornamental gold neck-chains. Nothing in art, he said, was absolutely new. However simple, however ingenious or seemingly original, so long as the forms and proportions commended themselves to our perceptions as beautiful and symmetrical, they were always to be found somewhere in nature, which was the storehouse at once of all great ideas and of all choice imagery and designs. Further to illustrate this, the lecturer cited the case of the common Ox-eye Daisy, the centre of which prefigures the crossing curves on the back of an "engine-turned" watch-cover. The same

may be seen in the centre of the China Aster and many other composite flowers.

*Rosa canina* was next passed under review, and the variety of it formerly distinguished by some botanists as *Rosa Forsteri*, the lecturer taking advantage of the opportunity to point out the distinctions between "species" and "varieties." Much, he remarked, of what he had stated was probably familiar to all the botanists present; but the Societies were established more for the benefit of the unlearned, and the greatest pleasure *he* experienced in life was the passing on to others who were only just entering on scientific inquiries, what he himself had acquired from year to year.

Thus far the proceedings, as we have described them, were characteristic of the *modus operandi* of the Manchester Society. We must now retrace our steps, for an instant, in order to show how the Liverpool Club carries out its objects.

On the arrival of the Liverpool party at Hoghton station, the honorary secretary, the Rev. William Bannister, distributed amongst the ladies a printed list, headed "L. N. F. C. Names of Natural Orders from Dr. Dickinson's 'Flora of Liverpool.'"

This list comprised 101 orders, beginning with "Ranunculaceæ," and ending with "Characeæ," each order being separated from the adjoining ones by perforated lines, so that the greatest facility was afforded for tearing off the the names of the orders.

The object of this proceeding was to enable such of the ladies as desired it to compete for the "Botanical Prize" (a book value 10s. 6d.); one of which is awarded at each excursion "to the lady who collects and arranges, according to the natural orders, the largest number of species in flower." Any specimen wrongly marked is rejected, and no lady is entitled to receive more than one excursion prize in the season. The last-named is an excellent regulation, enabling the less advanced botanists also to compete with some chance of success.

By way of parenthesis, we may mention that, beside the excursion prizes, the Liverpool Society grants thirteen others, varying in value from £1. 1s. to £5. These are season prizes, given for the following collections:—The best Hortus Siccus (3); Conchological (1); Geological (1); Microscopical (1); Zoological (2); Entomological (4); General (1).

During their rambles on the occasion in question, many of the ladies were busily occupied in the collection of plants; but, owing to the length of Mr. Grindon's excellent address, the judges (who are usually the two vice-presidents (the Rev. H. H. Higgins and Dr. Collingwood, F.L.S., along with one or more of the committee) were unable to award the prize to the successful competitress. This part of the proceedings was, therefore, postponed.

The same cause also compelled the Rev. Mr. Higgins to curtail his address, which was delivered by him, as the representative of the Liverpool Club, after the conclusion of that of Mr. Grindon. He referred to the general objects and rewards of societies such as those which were now so harmoniously mingling about him; to the beauty of nature, as awakening many of the noblest emotions of our minds, with the result, which scarcely ever fails to follow, of a larger and more religious apprehension of the world

around us; in every way promoting our happiness and genuine enjoyment of life.

The company returned to their respective homes at about eight o'clock; not a single untoward incident having occurred to mar the day's intellectual enjoyment.

## REWARDS AND HONOURS FOR PROFICIENCY IN SCIENCE.

THERE is probably not one young man in a thousand who is aware of the fact that if he makes himself acquainted with what every schoolboy should know, and every sensible lad ought to be delighted to learn in connection with almost any branch of science, he may pass a government examination, and receive a certificate, along with a book, or a gold, silver, or bronze medal, as a prize. And moreover, if he prefer rewards of a more substantial character, he may, at the expense of government, travel up to London and remain there during the half-yearly examination: having passed his examination, he may secure an honourable diploma as a teacher, and become entitled to an annuity varying in the aggregate from £10 to £40, if he returns to his native town and there establishes a science class. In addition, he will receive a fee for every pupil who, through his instrumentality, passes a government examination, and obtains a certificate. All these privileges are entirely irrespective of any charge which he may deem proper to make for tuition.

Last, but not least, he may, in following so honourable a profession, effect much good as a teacher of the humbler classes, instead of adding to the host of desultory lecturers who address empty benches in our halls and schoolrooms.

"Ay!" we hear some reader exclaim; "how well all that sounds in theory; but where shall I find the time necessary to prepare for such an examination?"

We will humour the diffidence of such a one, and suppose that his information on scientific subjects is of the most limited kind.

Say, for example, that he has acquired some knowledge in any particular branch of science. Geology, for instance.

Does he think he would be able to answer the following questions? because, if he can do so sensibly, he would, we think, obtain *at least* a third-class certificate, with the accompanying privileges and emoluments.

He need not be nervous or timid; the examiners, men of high attainments, are kind, considerate, and gentlemanly in their demeanour; indeed, they are anxious for his advancement. Moreover, they put their questions into print, and give him ample time to answer in writing.

"What is meant by a fossil?

"Into what two great classes have rocks been divided?

"By what means has the material in stratified rocks been arranged?

"Name some of the different kinds of rocks. (In this question I do not want the names of *formations*, such as Old Red Sandstone, Gault, &c.; but the common geological names of rocks, such as shale, granite, &c.).

"How does coal lie among the strata? and *how was it formed*? and what metallic ore is worked to a great extent in the coal measures?*

"Name any of the genera or species of fossils found in the oldest Tertiary or Eocene rocks?

"Name some of the kinds of fossils found in the Silurian rocks."

Some of the questions in the series are more difficult than those we have extracted; but the replies entitle the student to a higher degree and greater emolument.

Now let us turn for a moment to the subject of Animal Physiology, and inquire what is the nature of the information expected from the candidate in this branch of knowledge.

Here are the first six questions of the first series:—

"1. Of what chemical elements is animal flesh composed?

"2. What are the chief chemical components of bone?

"3. What is meant by 'organs' and 'functions?'

"4. What becomes of a piece of bread when you eat it?

"5. What is the use of saliva?

"6. What is bile, and where is it formed?"

Will any one assert that a person who is unable to answer these questions with ordinary accuracy has received a proper education?

They may be taken as the types of those which have to be answered in the other branches of science; but, of course, we do not recommend any of our readers, who are disposed to avail themselves of the advantages offered by the Science and Art Department, to be content with such elementary knowledge as this. Whilst we only give these examples to show how *little* will enable an industrious man to attain a certain position and earn an honest livelihood, we recommend all who have the time and ability to become as proficient as possible before presenting themselves for examination.

Science forms but a secondary element in the education of our youths, and consequently few teachers in schools have any knowledge on the subject.

These, the teachers, should lose no opportunity to improve themselves in this respect; otherwise, they may rest assured that better-informed competitors in this part of the "labour market" will soon supply their place, for the time is not far distant when a man who is unacquainted with the elements of scientific knowledge will be deemed as ignorant as we now consider one who can neither read nor write.

It therefore behoves the friends of education in every town or large village to second the good work of our government, by the establishment of classes and schools of science.

And now we must be permitted to give a hint to the Committee of Council on Education.

We find a constant repetition of the word "he" in the regulations of the Department, in speaking of teachers and candidates, and venture to suggest that the words "or she" be added; for, until they are, the movement will not be completely successful.

* This is one of the most difficult questions in the series, and its "value" (*i.e.*, the number of marks given for the answer) is a high one.

## QUARTERLY RETROSPECT.

AS we glance cursorily over the scientific events of the last few months, we cannot help being struck by the growing influence exercised by man over the powers of the universe—an influence whereby these forces are daily rendered more and more subservient to his purposes.

The subject by which our attention is especially arrested, is that of *Astronomical Photography.*

Not only does the glorious orb of day, by means of the warmth and light which it imparts, serve to sustain our vitality and that of the numerous tribes of plants and animals that surround us; not alone do its rays illumine all *Nature*, but they have been impressed into the service of *Art*, and are now employed as pencils to delineate and register the phenomena and changes to which the solar orb itself is subject.

At the recent meeting of the British Association for the Advancement of Science, Mr. Warren De la Rue made the following communication to the members:—

"I have obtained some sun-pictures, of very considerable promise, on the extremely large scale of the sun's diameter equal three feet. These pictures have only been very recently procured, and I submit them to the section because I believe that an interest is felt in the progress of celestial photography, and that our members prefer to take part in the experiments, as it were, by watching their progress, rather than to wait until the most favourable results have been brought about. I may state, the mechanical and chemical difficulties have been surmounted, and the only outstanding one is the form of the secondary magnifier. When this has been worked out, perfect sun pictures, three feet in diameter, will be obtainable with a telescope of one-foot aperture in less than the twentieth of a second of time. These pictures, when taken under suitable circumstances, may be grouped so as to produce stereoscopic pictures, which must throw considerable light on the nature of the spots."

But the enterprising artist of the heavens is not contented with the portraits that *our* sun furnishes of itself: the suns of other systems, with their attendant planets, must shed their lustre on his sensitive tablets, and map themselves to aid him in his studies and his speculations. He thus continues—

"We now know that the luminous prominences which surround the sun, for they do belong to him, can be depicted in from twenty to sixty seconds, on the scale of the sun's diameter equal ¼ of the object-glass employed. That is to say, an object-glass of three inches aperture will give a picture of the prominences surrounding a moon four inches in diameter.* The next subject I have to call your attention to is the photographic depiction of groups of stars, for example, such as form a constellation like Orion—in other words, the mapping down the stars by means of photography. I have made several experiments in this direction, and have obtained satisfactory results, and I believe that, at last, I have hit upon an expedient which will render this method of mapping stars easy of accomplishment."

Here the *astronomer* leaves the heavenly bodies for the present; but now the chemist "takes up the wondrous tale." Seizing their luminous rays, just released by his brother-investigator, he analyses them, and from their pale light

* This refers to the experiments made by the lecturer on the solar eclipse.

educes all the colours of the rainbow. Nor does he rest here, for by his exquisite tests he is enabled to pursue them to their sources, millions of miles distant, and from the composition of the emitted rays he traces that of the bodies whence they emanate. Soon we shall be fully acquainted with the constitution of the heavenly bodies ; shall know of what materials sun and moon and stars are formed !

The history of the recent discoveries connected with the solar and other spectra was ably narrated at the meeting to which we have just referred, by Professor W. A. Miller, of King's College, London ; but the subject is deserving of more than a passing notice, and we hope in our next number to be able to present it to our readers in a popular guise.

Let us not, however, quit the photographic art too hastily, for it leads us into other realms of nature. Passing from the inanimate to the animated world, we still find it busily at work.

The "Natural History Review" of last July contained an excellent photograph of the brain of a chimpanzee, in illustration of Mr. Marshall's paper on that subject ; and it has been very properly suggested that all works which will admit of it, more especially books of travel, and such as treat of new forms of life, should be thus illustrated as a guarantee for their accuracy.

This is no new idea. Who does not recollect the interest that characterized Mr. Piazzi Smyth's charming work on "Teneriffe," which was not only illustrated by photographs, but was accompanied by a folding stereoscope to aid in their inspection ? And now adieu to nature's artist.

The "brain of a chimpanzee" naturally reminds us of the animated discussion which has recently taken place between Professors Owen and Huxley concerning the cerebral development in man and the higher apes, in which the latter gentleman has sought to show that the difference between the two is not so great as physiologists have hitherto been led to believe. From the chimpanzee we naturally pass to the gorilla and M. du Chaillu.

In the absence of any communication having been published (at least so far as we are aware), from the Rev. Messrs. Wilson and Mackay, missionaries at the Gaboon, to whom, if our memory serves us aright, M. du Chaillu stated he should write for a verification of his narrative, we may say that we have it from an authentic source, that the traveller is well known to those gentlemen. Our informant has often heard him named by them as an adventurous explorer, who had penetrated far into the interior, but never as a naturalist or scientific man. Beyond this we have no desire to comment upon a dispute which has already occupied quite enough of the public attention.*

In regard to the great antiquity of man, it will doubtless have been observed by many of our readers, that the evidences in its favour are daily

* Since the above was written there has appeared in the *Advertiser*, *Athenæum*, &c., a letter from a Mr. R. B. Walker, to whom M. du Chaillu was well known. To a great extent he confirms the accounts we have received concerning him, but also accuses him of gross exaggeration, mendacity, and ignorance. The *Critic*, however, publishes two letters from the same gentleman, dated 1858 and 1859, in which he speaks of M. du Chaillu in very different terms.

gaining new advocates for the theory. The latest convert of importance is, we believe, Sir Roderick Murchison, who, at the recent meeting of the British Association, stated that

"He should not occupy time by alluding to the engrossing subject of the most recent natural operations with which the geologist had to deal, and which connected his labours with those of the ethnologist. On this head he would only say, that having carefully examined the detrital accumulations forming the ancient banks of the river Somme in France, he was as complete a believer in the commixture in that ancient alluvium of the works of man with the reliquæ of extinct animals as their meritorious discoverer, M. Boucher de Perthes, or as their expounders, Prestwich or Lyell, and others. He might, however, express his gratification in learning that our own country was now affording proofs of similar intermixture, both in Bedfordshire, Lincolnshire, and other counties; and, possibly, at this meeting they might have to record additional evidences on this highly interesting topic."

If, day by day, the telescope is enabling man to penetrate farther and farther into the distant heavens, and chemistry is rendering him cognizant of the constitution of the rolling orbs, so is the penetrating power of the microscope bringing within the range of his vision innumerable objects of beauty hitherto unknown to him, and investing the most commonplace subjects with fresh interest and wonder. Who would have dreamt that a piece of orange-rind could afford us opportunities for the study of entomology? But so it is.

Mr. Richard Beck has imparted new interest to this one of the most ordinary of our imported fruits.

He says (*Micr. Trans.* 47) that, "If the external surface of almost any of the sweet oranges be only cursorily examined, it will be found more or less spotted with small scales, the shields of a "Coccus" or scale-insect.* They are adherent to the rind of the orange, but can easily be detached; and on turning one of the larger ones over, it will be found, on examination under a low power, to present as the most striking feature a large accumulation of eggs lying beneath a cottony secretion."

Mr. Beck has minutely described the metamorphoses of this curious little insect; and he says that one single orange, if well selected, will supply every condition described by him. Many microscopists will, no doubt, be tempted to direct their attention to an interesting object so easily obtainable.

Every day fresh additions are made to the list of those exquisitely constructed and mysterious microscopical forms the "Diatomaceæ." Several new species have, during the last few months, been described and delineated by Dr. R. K. Greville, Dr. Donkin, and George Norman, Esq.

A few words more in regard to chemical science, and we must draw this imperfect review to a close. The question of the employment of Arsenic in colouring ladies' dresses, head-gear, &c., has caused some stir, and on this subject an obliging correspondent sends us the following communication, which will no doubt be found interesting to our readers:—

"Green Colours.—Scheele's, or the arsenical, green is in many respects a most objectionable and especially a dangerous colour. Elsner has intro-

* One of the "Hemipterous" order of insects, of which the well-known Aphis may be considered the type; and the family to which the cochineal insect belongs.

duced three new greens, which are very pleasing, and which are certainly not liable to the objections urged against the arsenical preparations.

"*The Elsner Green* is prepared by adding, first, sulphate of copper to a decoction of fustic, and then about ten per cent. of protochloride of tin. To this is poured an excess of caustic soda, whereupon a green precipitate falls. This, on being washed and dried, assumes a peculiar but pleasing *blue-green colour.*

"*Tin-copper Green.*—Fifty-nine parts of tin are heated in a crucible with one hundred parts of nitrate of soda. This is dissolved when cold in caustic alkali. The solution, being diluted with water and allowed to clear, is united with a solution of sulphate of copper. A reddish-yellow precipitate falls, which, on being washed and dried, becomes a very beautiful green.

"*Titanium Green.*—Titaniferous iron is fused with twelve times its weight of sulphate of potash. The fused mass is treated with hydrochloric acid, heated to 50° Cent. and filtered hot. The fluid is evaporated until a drop placed on a glass-plate solidifies. A concentrated solution of sal-ammoniac is poured over the mass, which is stirred and filtered. Titanic acid remains behind; this is digested with dilute hydrochloric acid, and a solution of prussiate of potash being added, the mixture is heated to boiling as quickly as possible. A green precipitate falls, which must be washed with water acidulated with hydrochloric acid and dried at a temperature under 100° Cent. The result is a beautiful dark-green powder."

And now we must for the present bid farewell to the reader. Our anxiety to allot as much space as possible in this, our first number, to correspondents for the insertion of instructive articles has necessarily compelled us to curtail our quarterly gossip on scientific events, and in so doing we trust that we have secured the approval of our readers, to whom we shall at all times endeavour to afford the greatest possible amount of interesting and instructive information.